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THE NON-METALLIC MINERAL RESOURCES *of* MANITOBA



STRUCTURAL AND BUILDING
MATERIALS — FUELS —
MISCELLANEOUS MINERALS

BY
R. C. WALLACE
and L. GREER

ISSUED AND DISTRIBUTED BY
INDUSTRIAL DEVELOPMENT BOARD
OF MANITOBA

WINNIPEG
1927

429976

PREFACE

THE non-metallic minerals of Manitoba are an asset of considerable value to the province. They lie reasonably closely to hand; they are mainly of value in building construction and in road work, in which fields there is much to do as the agricultural population increases; and in many ways they will assist in the development of industrial undertakings in the province. They have as well been responsible for almost the whole mineral production in Manitoba to date.

The production of non-metallics now shows a very steady increase; but with the opening up of the metallic mineral resources of northern territory it is probable that the non-metallic mineral production will soon be outdistanced by that in gold, copper, zinc and silver.

The various mineral materials have been arranged alphabetically under related groups—the structural and building materials, the fuels, the miscellaneous minerals. Of these the group of structural and building materials is the most important, and is dealt with at greatest length. The aim is to present the material in a way which will assist in the building up in the province of industrial life based on the natural resources which lie at hand. Investigations in non-metallics have been carried on during the field seasons of 1926 and 1927.

October, 1927.

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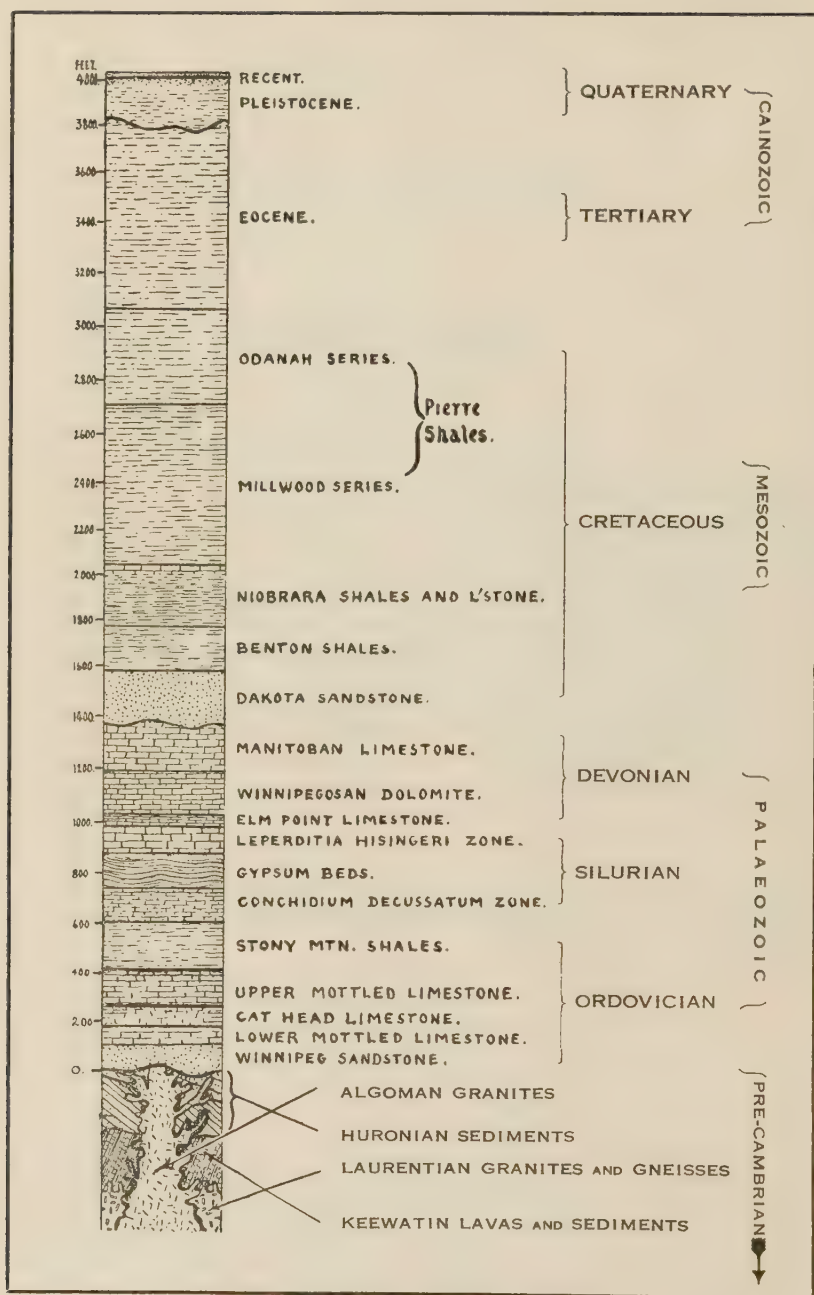
The Board is prepared to render competent advice and service to existing industries and to supply, without cost or obligation, authentic information regarding the resources and industrial advantages of Manitoba.

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Column of Geological Formations in Manitoba.

I.—Structural and Building Materials

BUILDING STONE

Four kinds of stone have been used in Manitoba for building purposes, viz.:

1. The Upper Mottled Ordovician limestone of East Selkirk, Lower Fort Garry, St. Andrews Locks, and Garson.
2. The dolomite of Stonewall.
3. The sandstones south of Boissevain.
4. The granite and gneissoid boulders brought down from the north by the ice.

East Selkirk—

Until about 25 years ago the chief production of building stone came from three small quarries at East Selkirk, among buildings in which it was used being the Customs House at Winnipeg. The East Selkirk stone, however, was later replaced in favor by the stone from Garson, the latter being less broken up, more easily quarried and darkening less on exposure.

Lower Fort Garry—St. Andrews Locks—

Stone of the same horizon and very similar in appearance to the Garson stone, occurs at St. Andrews Locks and Lower Fort Garry. The Fort and the Selkirk Asylum are examples of its use. The heavy drift covering makes profitable extraction impossible under present conditions.

Garson—

The Upper Mottled division of the Ordovician system occurs in splendid quarry beds at Garson and has been utilized as a building stone for a number of years. "The stone is a soft limestone with a characteristic mottling in darker colors. Two types are recognized—a buff variety and a blue variety. The former type is generally preferred by architects, but a considerable amount of the blue stone is also used. Both varieties can be quarried in large blocks and both are capable of being dressed and carved with ease." (*)

The area where stone is known to be available extends in a north and south direction for a distance of about 3 miles, reaching from the north halves of sections 33 and 34, Tp. 12, Rge. 6E., through sections 6 and 9, Tp. 13, Rge. 6E., to the N.W. quarter of section 15, Tp. 13, Rge. 6E. The drift is heavy on much of this however, and "the main productive ridge is quite narrow, probably not more than a half-mile wide." (*)

(*) Report on the Building and Ornamental Stones of Canada—Vol. IV, 1916—Mines Branch
—Department of Mines—by W. A. Parks.

Recent production has been confined to three adjoining quarries at Garson village, on Sec. 3, Tp. 13, Rge. 6E, immediately south of the Winnipeg-Lac du Bonnet highway. Work has been resumed lately on the Independent quarry, about 3,000 feet to the northwest.

A system of lettering the beds guides the quarrymen in their work. The accompanying diagram indicates the beds present in each quarry, their thickness, and some of the partings. The latter may be easily confounded with the primary bedding and are probably responsible, in part at least, for the variations in the figures given for thickness.

Quarrying—

The system followed is identical in all the quarries. First, all the drift and broken stone is loaded by pick and shovel into wagons and hauled away. Sometimes a small steam shovel is used. Next, a steam channelling machine cuts oblong strips of any desired width and thickness. Then a row of shallow holes is put down across the strips by an air drill, so as to give stone of any specified length. Wedges driven into these holes by hammer bring about the necessary splitting. The block is broken off from the underlying bed by introducing wedges along the bedding plane. The stone is then free and is lifted out by a powerful derrick and loaded on flat cars, ready for shipment to the mill.

The stone below the K bed is very hard—so hard that it is doubtful if it could be quarried without excessive cost.

Quarrying seldom extends into the winter months, for unless the stone is brought under shelter immediately and allowed to season, the frost causes the loss of as much as 50%. The usual practice is to quarry sufficient stone in the summer to fill any winter orders.

Drainage is not a serious problem, but a certain amount of water accumulates and must be pumped out.

A brief description of the operations of the three companies follows:

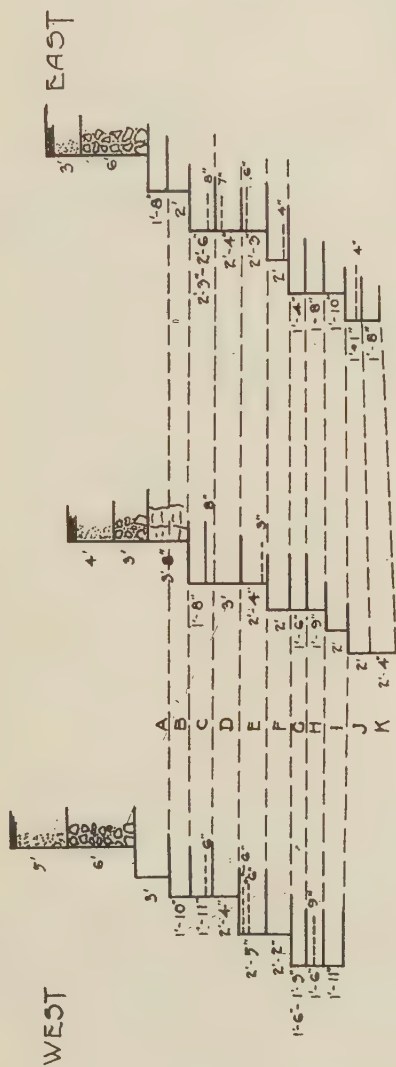
Tyndall Quarry Co.—

This property is the most easterly of the three quarries.

The present workings are in an opening about 450 feet square and 27 feet deep. 18 feet of effective stone are exposed on the main face.

Though there are occasional joints striking about N.66°E, and a secondary system running about S.43°W; they are not so frequent as to cause difficulty. Blocks up to 3' 6" in thickness are sometimes obtained.

The output and number of men employed are strictly dependent on the demand for stone. In 1926, which was a busy



GILLIS QUARRIES LTD. WESTERN STONE CO. TYNDALL QUARRY CO.

FIG. 1 THE QUARRY BEDS AT GARSON
DRAWN TO VERTICAL SCALE

year, the working of the quarry required the services of 30 men, and 250 cars of stone were shipped, about 50% being buff. Sixty cars of rip rap were sold, mostly to the railroads.

LIST OF MAIN EQUIPMENT AT QUARRY—

- 2 steam channellers
- 2 hoists
- 1 $\frac{3}{4}$ -yd. steam shovel
- 1 compressor
- 1 power-house, developing about 25 h.p.

The company operates a stone mill at 1591 Erin Street, Winnipeg, where most of their stone is finished. Approximately 20 men are employed.

LIST OF MAIN EQUIPMENT AT MILL—

- 2 double diamond saws—72" blades
- 1 single diamond saw—80" blade
- 1 single diamond saw—60" blade
- 2 gang saws
- 2 double planers
- 2 single planers
- 2 air compressors
- 2 electric travelling cranes
- 3 hand travelling cranes
- 2 electric derricks

The mill is completely electrified; approximately 250 h.p. is used.

Western Stone Co.—

This company's main quarry is directly west of that of the Tyndall Quarry Co. The S.W. forty acres of the northeast quarter of Sec. 9, Tp. 13, Rge. 6E, on which is located the Independent (Wm. Henry) quarry is also held.

The present quarrying operations are in an opening about 300 feet long and 150 feet wide. A maximum thickness of 22 feet of effective stone is exposed on the quarry face. Less buff stone is quarried here as the A and B beds are badly broken and must be discarded. Occasional vertical joints, striking about N.68°E, are encountered.

A private line to the Winnipeg Hydro transmission line has been leased and supplies power for the mill and quarry. About 465 h.p. is used. It is planned to supply the other quarries.

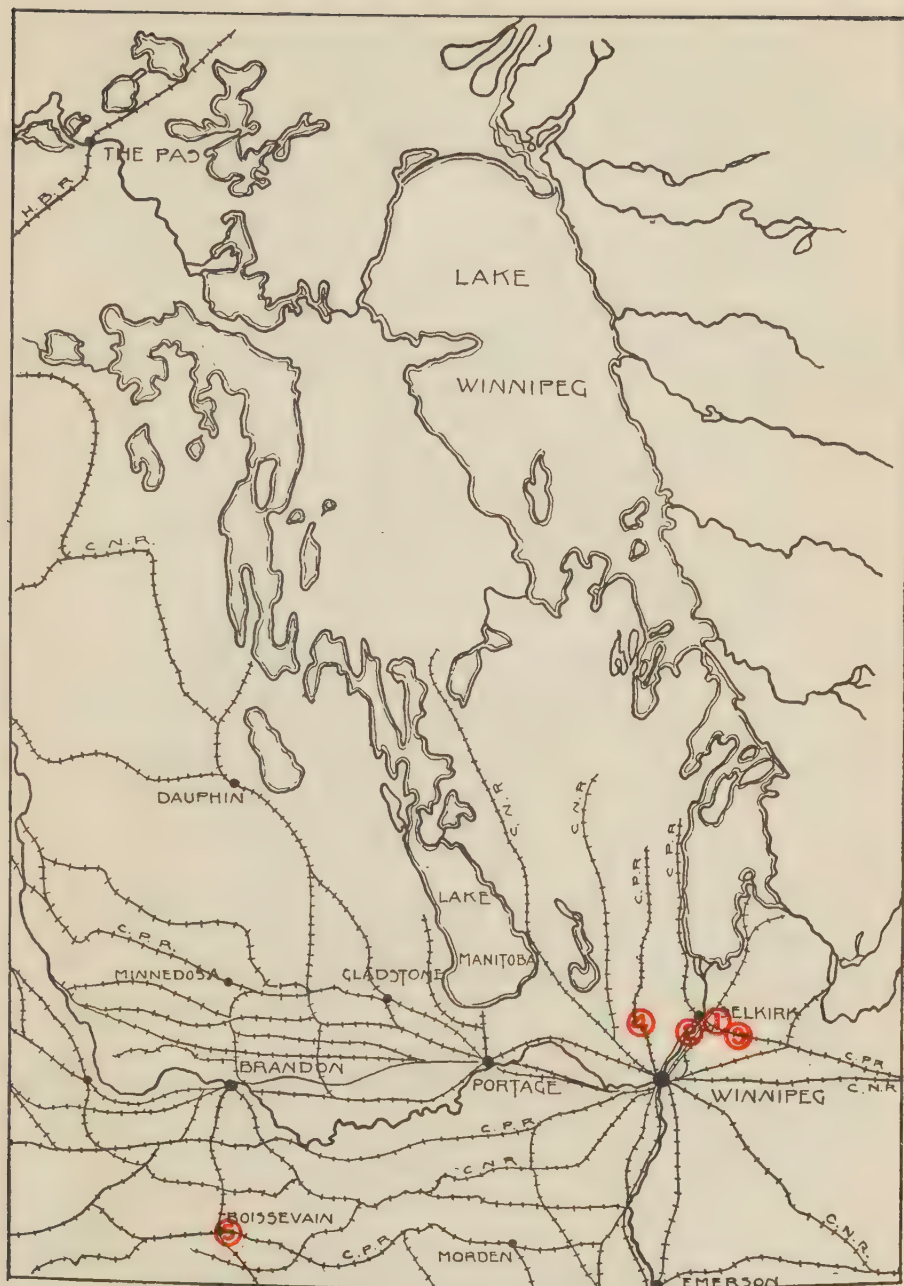


Fig. 2—Building Stone Occurrences—

- | | |
|---------------------------------------|---------------------|
| 1. East Selkirk | 3. Garson (Tyndall) |
| 2. Lower Fort Garry—St. Andrews Locks | 4. Stonewall |
| 5. Boissevain | |

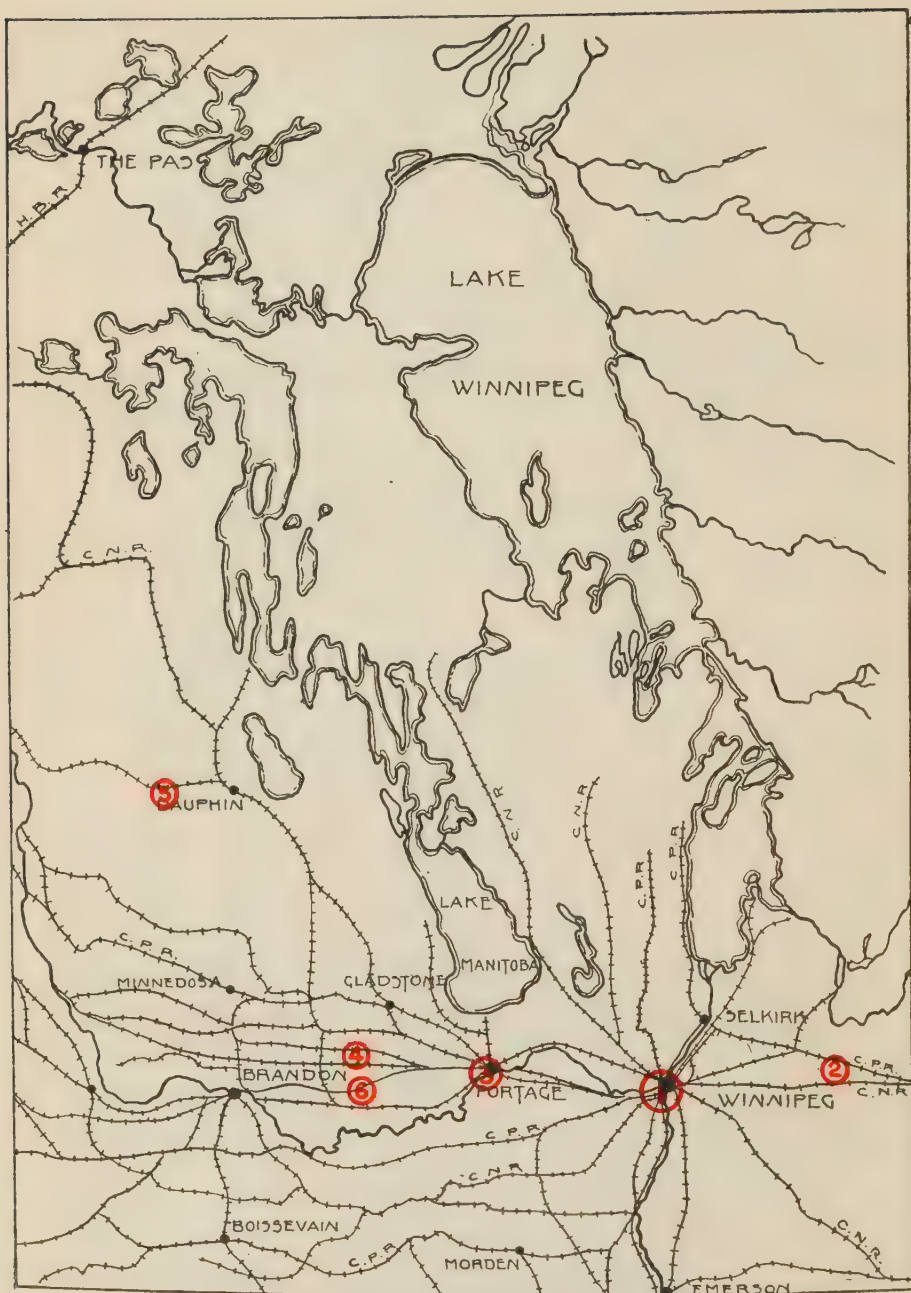


Fig. 3—Manitoba Brick Yards—

- | | |
|--------------------------------|-----------------------------------|
| 1. Winnipeg (Alsip and Marion) | 4. Edrans (National Clay Product) |
| 2. Whitemouth (McCutcheon) | 5. Gilbert Plains (Snyder) |
| 3. Portage la Prairie (Snyder) | 6. Sidney |

In 1926, more than 135 men were employed in the mill and quarry.

LIST OF MAIN QUARRY EQUIPMENT—

- 4 derricks—2 steam and 2 electric
- 2 steam channellers—1 single and 1 double
- 2 compressors
- 1 power plant
- 1 donkey locomotive—does switching for all three companies

This company is the only one possessing a mill at Garson. It is situated beside the quarry, and is very complete. Considerable savings in freight charges are thus effected.

LIST OF MAIN EQUIPMENT IN MILL—

- 1 double diamond saw—84" blades
- 2 double diamond saws—60" blades
- 2 double diamond saws—36" blades
- 1 single diamond saw—59" blade
- 1 single diamond saw—72" blade
- 1 carborundum saw—adjustable from 4" to 18"
- 2 turning lathes, one for columns and one for balustrades
- 2 double planers
- 2 single planers
- 1 large double split table
- 2 rubbing beds
- 4 polishing machines
- 3 electric travelling cranes
- 2 electric derricks
- 1 complete machine shop, capable of doing all repair work

In addition the company operates a small finishing mill at Montreal, where considerable stone is handled.

The Independent quarry has been acquired recently and work has been resumed on it. Previously an opening about 75 feet by 100 feet had been made. A good deal of dead-work is necessary to get it into shape.

Between eight and nine feet of stripping overlies the stone. The two upper beds total 3 feet 8 inches in thickness. They are rather shattered, but stone of a fair size may be taken out. Thirty-five feet of marketable stone is said to occur. This quarry is credited with the possession of the best buff stone of the district.

Gillis Quarries, Ltd.—

The property consists of the N.W. quarter of Sec. 3, Tp. 13, Rge. 6E, and the quarry itself is approximately 1,000 feet west of the Western Stone Company's quarry.

The present workings are in an opening about 450 feet by 130 feet, and about 26 feet deep. There are occasional joints striking about N. 68E. In places the stone of the A and B beds contains a good deal of clay, this being more or less true of the other quarries. The beds dip slightly to the southwest. Buff stone up to 3 feet 6 inches in thickness can be obtained from the B and C beds.

Some 20 men are employed in the quarry. The output in 1926 amounted to 6,400 tons of rough stone. In addition 20,304 bushels of lime were produced, waste stone being burned.

LIST OF MAIN QUARRY EQUIPMENT—

- 1 steam channeller
- 2 derricks
- 2 compressors
- 1 powerhouse
- 4 kilns, 2 operating intermittently.

The stone is finished at the company's mill at Winnipeg. Thirty men are employed.

MILL EQUIPMENT—

- 1 single diamond saw, 84" blade
- 1 double diamond saw, 72" blades
- 2 single planers
- 1 double planer
- 1 single rubbing table (2 sides)
- 1 double rubbing table
- 2 electric cranes
- 1 air compressor
- 1 derrick

Approximately 200 h.p. is required.

The following table indicates the results obtained from tests. (*)

	Blue	Buff
Specific gravity.....	2.767	2.741
Weight per cu. ft., lbs.....	151.24	152.88
Pore space, per cent.....	12.17	10.55
Ratio of absorption, per cent, one hour.....	1.076	1.595
Ratio of absorption, per cent, two hours.....	2.702	2.296
Ratio of absorption, per cent, slow immersion.....	3.816	3.841
Ratio of absorption, per cent, in vacuo.....	4.57	4.296
Ratio of absorption, per cent, under pressure.....	5.01	4.296
Coefficient of saturation, one hour.....	0.21	0.37
Coefficient of saturation, two hours.....	0.54	0.53

(*) Report on the Building and Ornamental Stones of Canada (Vol. IV., 1916, Mines Branch Dept. of Mines), by W. A. Parks.



PLATE I.

1. Rock crusher, City Quarry, Stony Mountain, looking north-east.
2. Steep Rock Quarry, looking north. Shovel in operation.
3. Anticlinal fold in gypsum beds, north end of quarry, Gypsumville.
4. Sampling Spodumene outcrop on Miller Lithia property, east of Bernic lake.
5. West Quarry, Gunton, with crushers of east and west quarry, looking east.

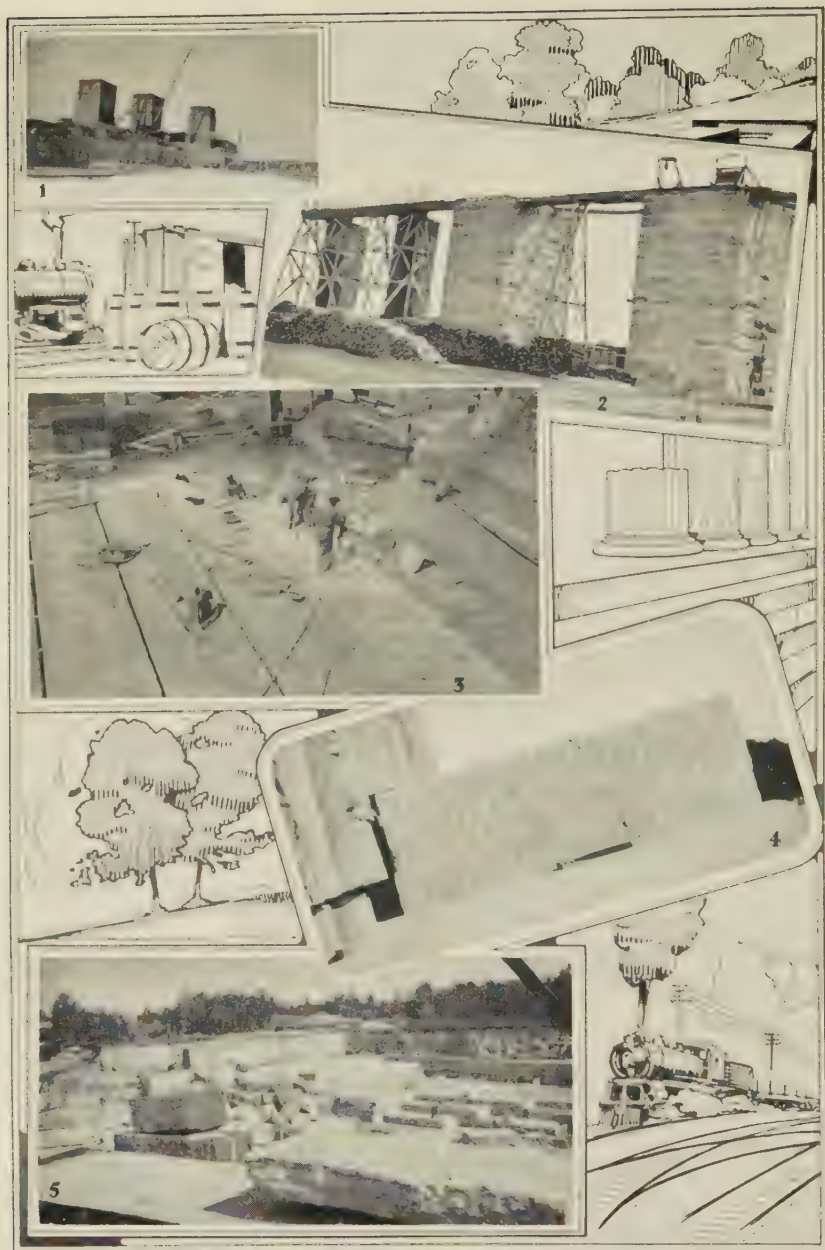


PLATE II.

1. Lime Kilns at Stonewall.
2. Lime Kilns at Gillis Quarry, Garson —the two cylindrical kilns now in use.
3. Gillis Quarry, Garson, Man., showing quarry methods. (Tyndall limestone)
4. Cut Stone, Western Stone Quarry, Tyndall, on bedding plane.
5. Western Stone Quarry, Garson, looking south-east.

	Blue	Buff
Coefficient of saturation, slow immersion.....	0.76	0.89
Coefficient of saturation, in vacuo.....	0.91	1.00
Crushing strength, lbs. per sq. in., dry (Average).....	10,033	10,006
Crushing strength, lbs. per sq. in., wet.....	8,000	8,357
Crushing strength, lbs. per sq. in., wet, after freezing.....	8,818	9,012
Transverse strength, lbs. per sq. in.....	1,382	1,297
Shearing strength, lbs. per sq. in.....	1,063	1,048
Loss on corrosion, grams per sq. in.....	0.158	0.182
Drilling factor, mm.....	30.0	20.0
Crushing factor, grams.....	11.30	9.90

It will be noted that the figures for crushing and transverse strength are rather low. The ease of carving, appearance and formational advantages, however, more than counterbalance this deficiency.

The mottling is very striking and has played a considerable part in creating the popularity of the stone. While not suitable for face or figure sculpturing, it has a truly fine appearance when employed in any other manner. Beyond a doubt it is one of Canada's most desirable building stones. Noteworthy examples of its use are the Legislative Buildings, Winnipeg; the Parliament Buildings, Ottawa (as an interior finish), and the St. Roch Cathedral, Quebec.

Markets—

Tyndall stone has had little or no competition in the prairie provinces, but it is only within the last three or four years that it has become widely used in eastern Canada. It is now well established in the market, and all signs point to a continually increasing use.

Owing to the high duty on cut stone, the Bedford (Indiana) limestone can no longer offer serious competition; though in the rough it still can compete. The Manitoba stone is not quite so easily worked, but has a considerably more effective appearance.

Stonewall Dolomites—

The Stonewall dolomite has been used for rough-face work in the Land Titles Building, Post Office, and School at Stonewall. It has a very handsome appearance in the rough and does not seem to darken on weathering. Only the lower beds are of sufficient thickness for building stone and it is so hard to work that further development except for local use seems unlikely.

Sandstone—

The only known occurrences of a sandstone suitable for building purposes, are at various places along the base of Turtle

mountain in southern Manitoba. During the early 90's of the last century, several small quarries were operated in the vicinity of Boissevain and the stone was used in a number of buildings in the town, notably the school, Methodist Church, and the Dominion Bank. The formation is probably Foxhill (Upper Cretaceous). It does not appear to be continuous, but occurs in lenticular masses. Typically the stone is a medium-grained greenish-grey sandstone, and hardens on exposure. Though rather thin bedded, it has proved satisfactory for building purposes. There is no longer any production due to the increasingly heavy overburden, the broken character of the stone, and competition of other building materials.

Granite Boulders—

The promiscuous scattering over the prairies of pre-Cambrian boulders, mainly of granite, is one of the results of the extensive glaciation which this province has undergone. In the absence of other structural materials they have been used to some extent for building purposes. The best examples in Manitoba of such work are the Court House at Morden, the Mission Church at Pine Creek on lake Winnipegosis, and the Indian Industrial School (R.C.) at Cross Lake.

CEMENT ROCK

Two companies in Manitoba supply cement to Western Canada, viz.: The Canada Cement Co., (Portland Cement), with a quarry at Steep Rock and a mill at Winnipeg, and the Commercial Cement Co., (Natural Cement), with a mine and mill at Babcock.

Canada Cement Co.—

Portland cement is an artificial product of fairly definite composition, containing approximately 60 to 65 per cent lime, 20 to 25 percent silica, and from 5 to 12 percent iron and aluminum oxides, and is formed under the action of intense heat. The necessary conditions are, intimate mixing of clay and limestone—this being brought about by fine grinding—burning of the raw mix at a very high temperature, a clinkered mass being formed, and finally, fine grinding of the clinker.

At the Tuxedo plant of the Canada Cement Co., approximately three parts of crushed limestone, 2 in. size, are mixed with one part of clay, the mixture then being ground to 200 mesh by batteries of ball mills and tube mills. The raw mix is next clinkered in 10'x150' rotary kilns for 2½ hours at 2,600° F. In order to retard the initial set of the cement, a small amount (3.6%) of gypsum is added. Lastly the product is reduced to 200 mesh in ball mills and tube mills.

CRUSHING PLANT AT
STEEP ROCK, MAN.

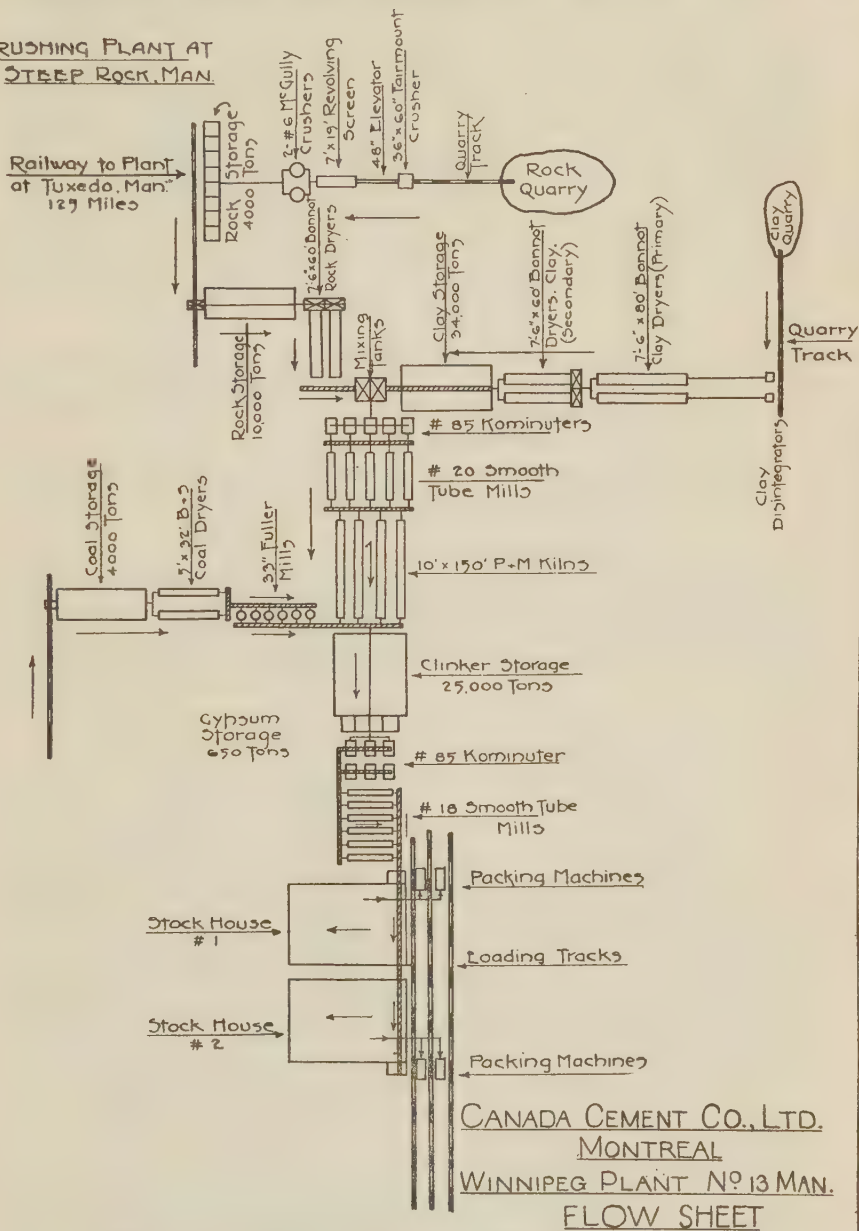


Fig. 4—Flow Sheet, Canada Cement Co's Mill, Winnipeg

Limestone is shipped from Steep Rock, 146 miles to the north, the quarrying operations there being described under the heading "Limestone." Clay is excavated by steam shovel near the mill and hauled in by a gasoline locomotive. The flow-sheet (Fig. 2) shows in detail the plant layout. Electric power is used throughout, being supplied by the Winnipeg Electric Co. who maintain a sub-station near the mill, generating approximately 4,000 h.p. More than 4,500 tons of gypsum are required annually and from 150 to 200 tons of Alberta coal are burned daily; 4,000 barrels of cement can be turned out per day, though of recent years the plant has been running at about half-capacity. During the operating period some 125 men are employed. No work is carried on in the winter months, sufficient cement being kept on hand to supply the market until spring.

Over 600,000 barrels were produced in 1926, this representing a large increase over the output of the previous year. The Portland cement requirements of the area between Dryden and Moose Jaw are met by this plant.

The cement itself is so well known that a description of its properties and uses would be superfluous.

Commercial Cement Co.—

At Babcock the Commercial Cement Co. produced cement during the period 1907-1924. An eight foot bed of calcareous shale of Niobrara age was mined. The following partial analyses supplied by Mr. Otto Babcock, indicate the composition of the shale.

	I	II
	Percent	Percent
SiO ₂	14.31	14.01
Al ₂ O ₃ + Fe ₂ O ₃	11.22	11.30
CaO	38.39	39.17

The Company's holdings consist of Sec. 11, Tp. 6, Rge. 8W. Immediately south of the C.N.R. track and about 15 feet higher, an adit has been driven into a hill, the side of which has been cut down by erosion incidental to the carving out of the Boyne river valley. The practice has been to run east and west tunnels, cutting out rooms north and south from the tunnels. The rooms are from 60 to 100 feet in length, 30 feet in width and are timbered through the centre by two posts and a cap. Pillars are from 15 to 30 feet square. Mining was carried on by hand steel. After loading the rock into tram cars, it was pulled by ponies to the mine entrance.

A trestle extends from the entrance across the track to the top of a battery of six continuous upright kilns. The trams were hauled up the trestle and the rock dumped into the kilns along with Youghiogheny screenings. A temperature of approximately

1,800° F. was reached. About 12 hours in the fire zone were required to clinker the rock, the cool clinker being drawn two days later.

After culling out the underburnt and overburnt product, it was sent to the mill for grinding, first being put through a gyratory crusher, then elevated and sent through a roll crusher. Final grinding to 100-mesh was carried on in a tube mill. The cement was shipped in cotton sacks and marketed as "Commercial Cement." A typical analysis follows:

	Percent
Loss on ignition.....	4.83
Insoluble residue.....	2.30
SO ₃	4.91
Fe ₂ O ₃	3.55
Al ₂ O ₃	10.43
SiO ₂	20.08
CaO.....	52.44
MgO.....	0.72

250 barrels could be produced daily. Between 14 and 23 men were employed.

Unlike Portland cements, natural cements are not made by burning carefully prepared and finely ground artificial mixtures, but by burning masses of natural rock. For this reason and because of the type of kilns used, they are less uniform in composition. Accordingly, the need for close inspection of the product is at once apparent.

The essential components of a normal Portland cement are, according to Rankin (*), tricalcic silicate, dicalcic silicate, and tricalcic aluminate. Although the exact constitution of Commercial Cement is not known, it seems to have a greater proportion of dicalcic silicate than has the Portland cement. This probably accounts for the fact that it will not give as high values when undergoing tests for tensile and compression strength.

Commercial cement is of a rapid hardening type which has given good results when used as a mortar. It would seem that it can be employed to best advantage in this work. Aside from its use as a mortar, the practice has been to mix it in equal proportions with Portland cement, in this way increasing the strength and retarding the initial set. This fifty-fifty mixture has proven satisfactory in concrete work where a high compression strength is not essential.

The best customer for Commercial Cement has been the City of Winnipeg, which has used large quantities of it for street and sidewalk work. A good deal has been used as a mortar in buildings. Small shipments have been made as far west as

(*) Portland Cement (Journal Franklin Institute, pp. 747-784, 1916), by G. A. Rankin.

Saskatoon and east to Dryden. It is to be hoped that the building revival will create a demand sufficient to justify re-opening the plant. Cheap electrical power should soon be available as the Manitoba Power commission has recently announced that its line is to be extended northwards from Miami to Rathwell, passing through Cardinal, only six miles west of Babcock.

CLAYS AND SHALES

THE BRICK AND TILE INDUSTRY

Extent of Industry—

There are two sources of materials in Manitoba for the brick and hollow tile industry—the surface clays and the shales of earlier age, mostly Cretaceous, interbedded with other rock formations in the province. The surface clays have been much more extensively used than the older shales and clays, and are the exclusive raw materials at the present time. These clays are operated at Winnipeg, (Alsip Brick and Tile Company); Whitemouth, (McCutcheon); Portage la Prairie, (Snyder); Edrans, (National Clay Products); and Gilbert Plains, (Snyder). Surface clay is excavated as well at Firdale, to mix with the Winnipeg surface clay at the Alsip plant for rough face brick. This represents the operations in the province at the present time (apart from two sand lime brick plants in Winnipeg), and is a small list in comparison with that of the time of building expansion in 1908-1913, when there operated as well on surface clays, brick plants at Lac du Bonnet, St. Boniface, Balmoral, Morris, Carman, Somerset, Rapid City, Cypress River, Hartney, Brandon, Neepawa, Lavenham, Sidney, Brookdale, Virden and Thunder Hill. There operated as well on the carbonaceous shales of the Niobrara formation (Cretaceous) a pressed-brick plant at Leary's, and on the Pierre (Cretaceous) shales, a pressed-brick plant at La Riviere. Somewhat later, a very complete brick and sewer piping plant was established at Carman, at which it was proposed to mix the shales from these two horizons; and more recently, another similar plant at Winnipeg (Winnipeg Clay Products, Ltd.). None of the brickworks established to operate on the older shales are now active, and the La Riviere and Carman plants have been dismantled.

The Clays—

The surface clays, on which operations are now based, vary somewhat in the different parts of the province. As a rule

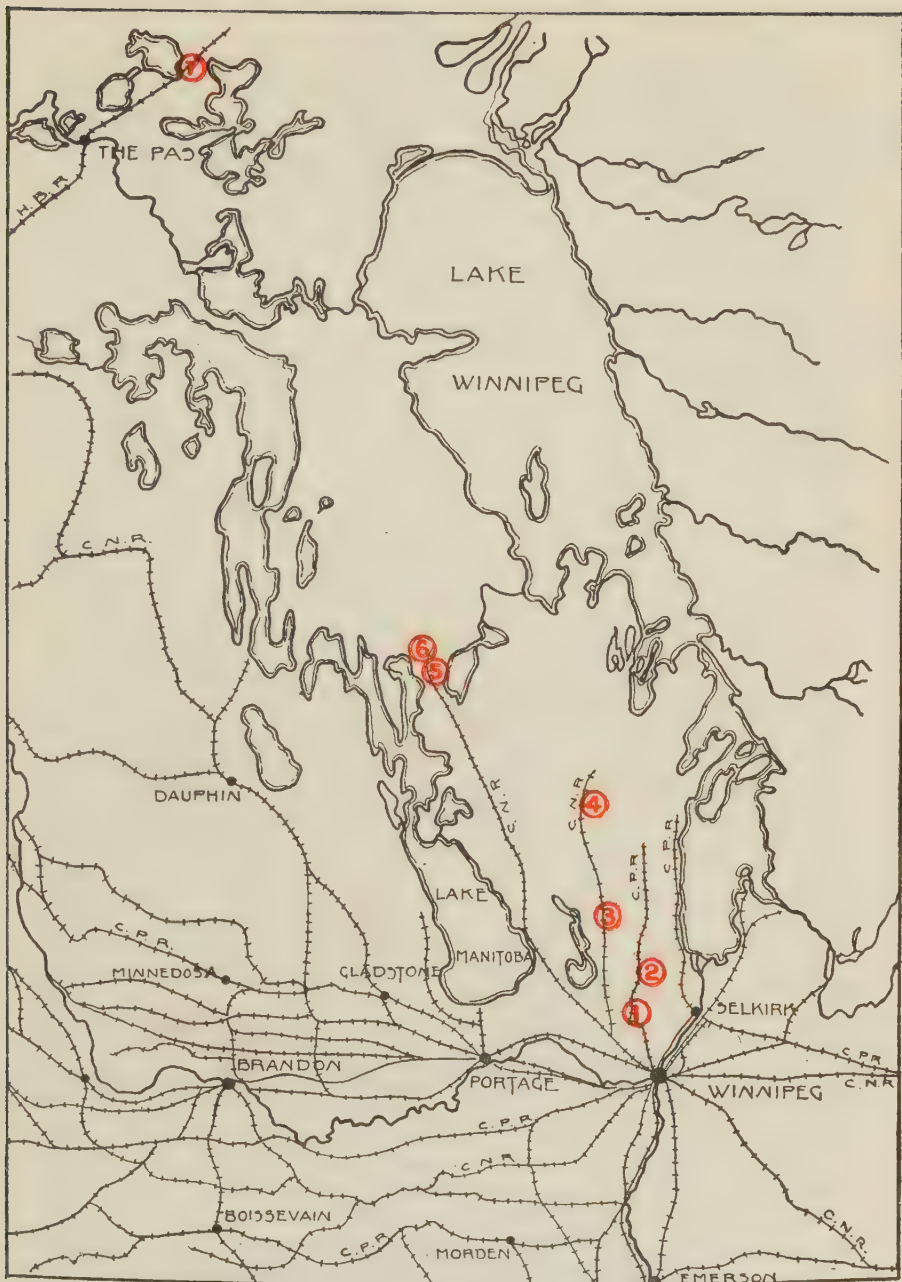


Fig. 5—The More Important Dolomite Occurrences—

1. Stonewall
2. Gunton
3. Inwood
4. Broad Valley
5. Fairford
6. Old Gypsumville
7. Mile 42—Hudson's Bay Railway

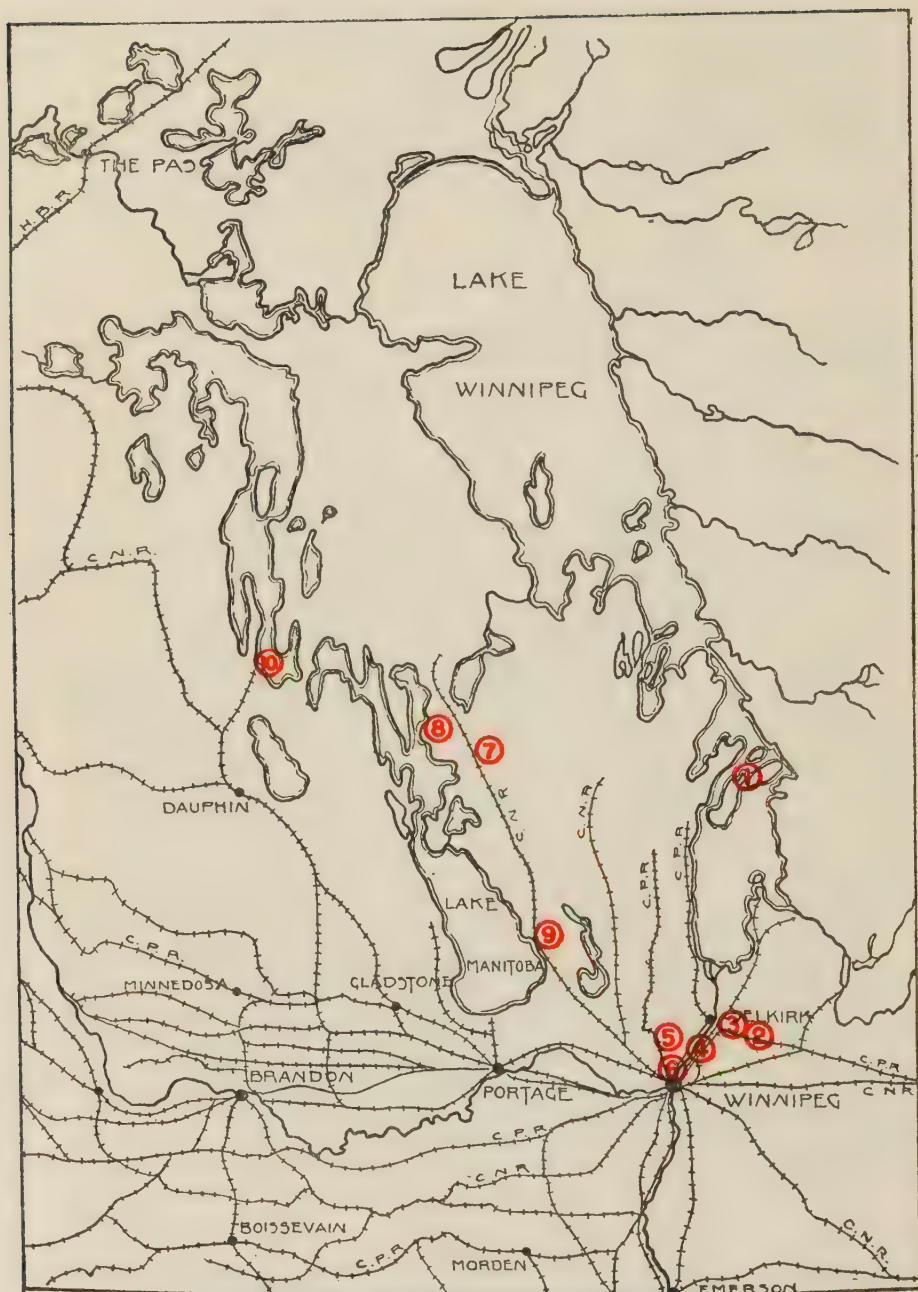


Fig. 6—The More Important Limestone Occurrences—

- | | |
|---------------------------------------|--------------------------|
| 1. Hecla island | 6. Little Stony mountain |
| 2. Garson | 7. Spearhill |
| 3. East Selkirk | 8. Steep Rock |
| 4. Lower Fort Garry—St. Andrews Locks | 9. Oak Point |
| 5. Stony mountain | 10. Winnipegosis |

they are lake or river deposited; where river deposited, they frequently contain lenses of sand which serve to mix with the otherwise fairly stiff clay. Where high in lime, as at Winnipeg, St. Boniface, Whitemouth and Portage la Prairie, the resulting brick is white or pale buff in color, the lime taking up the iron to form a colorless lime iron silicate. On the edge of the sand hills of the old Assiniboine delta, on the other hand, at Lavenham, Sidney, Firdale and Edrans, where the lime content in proportion to the iron is lower, the clay burns to varying shades of red to chocolate brown. The surface clay is also of varying degrees of plasticity, the plasticity increasing towards the Red river valley, where the underclays, underneath the 3 feet of clay now used for brick, are so highly plastic that they are not capable of manufacture without special treatment. With the highly plastic clays there may occur checking on air drying through excessive shrinkage, and care is taken to prevent too rapid drying. The surface clays of the Winnipeg area have a high fusion temperature, and the bricks have been found to stand prolonged contact with the surface soils and clays without any evidence of disintegration.

The relationship of the surface clays now being operated east of Red river at Alsip's and Marion's to the underlying clays is shown in sections on the Red river to a depth of 20 feet. The upper three feet underlying the soil is probably river deposited, and contains in places sand lenses. This has been used for many years in St. Boniface for brick manufacture. The underclays, which are remarkably uniform in composition, are parallel bedded and very finely laminated; they were deposited beneath glacial lake Agassiz. If there can be found sufficient demand to justify pre-heating treatment, a very large supply of uniformly good clay would be available in Winnipeg and St. Boniface for all the demands which may be made for brick and tile. Outside the Red river valley the surface clays are not of lake Agassiz origin, and vary considerably from place to place. At Whitemouth, $3\frac{1}{2}$ to 4 feet of clay are used below 1 foot of soil. The upper beds are sandy, resting on heavier—apparently lake Agassiz—beds. Both types are banded with almost varve-like regularity. At Portage la Prairie 7 to 8 feet of clay are used underneath $1\frac{1}{2}$ to 2 feet of soil. The clay shows no stratification, and is more sandy in the upper 4 feet than at the bottom of the pit. A 2 inch bed of soil divides the clay section into an upper 4 feet and a lower 3 to 4 feet. The clay is probably river deposited. At Sidney a 12 foot clay section with interbanded sand lenses was operated underneath 2 feet of soil. This is re-assorted material from the Assiniboine river delta in lake Agassiz, and is high in sand. At Edrans, a 3 to 4 foot section of clay is excavated with horse scrapers. It lies on the side of a beach (lake Agassiz) and contains a considerable number of limestone pebbles which are screened from the clay. At Gilbert Plains a cut of 4 feet is taken, including the surface soil which is less than a foot in thickness. At the east

end of the pit the clay is high in sand. The clay and sand are apparently river deposited.

The Shales—

In the Cretaceous and early Tertiary horizons in Manitoba there is a total thickness of approximately 2,200 feet of shales. The Cretaceous shales occur in the southwestern part of the province and their eastern edge is marked by the Manitoba escarpment, a line of hills—Pembina hills, Tiger hills, Riding mountain, Duck mountain, Porcupine mountain—which are relics in the erosion of the shales. Turtle mountain, near the southwestern corner of the province, is built up mainly of Tertiary shales. The relationship of the shales is shown on plate 6. The Cretaceous shales are—from bottom to top—of Benton, Niobrara and Pierre age. Of these the Niobrara shales have been used at Leary's for pressed brick, a mixture of the Niobrara and Pierre shales was used at Carman for sewer piping, and Niobrara shales from Morden and Pierre shales from La Riviere have been mixed for hollow tile at the Winnipeg Clay Products plant. Pierre shales were manufactured into dry pressed brick at La Riviere until 1912, but the plant is now dismantled. Elsewhere the shales have not been used in the province, and the Tertiary shales of Turtle mountain have not been utilised for brick manufacture.

The Benton shales are as a rule highly carbonaceous, and would be difficult to burn. The Niobrara shales as used at Leary's are also carbonaceous, and demand careful burning to avoid puffing and black cores. They are however highly plastic and easily worked, and burn to a good deep red color. They are moderately refractory. The Pierre shales are highly refractory, almost of the nature of fireclays, and fuse at about 2,600°F. They have very low plasticity, and as they occur as thin brittle slate-like shales they are somewhat difficult to work down, and could only be handled in a dry press plant. In order to increase the plasticity, and at the same time take advantage of the highly refractory nature of the shale, it has been suggested by Ries and Keele that mixtures be made of the Pierre and Niobrara shales from Morden and La Riviere respectively.

The most highly refractory shales immediately underlie the Dakota sandstone exposed in the Swan river valley, about 8 miles below Swan River (S.E. $\frac{1}{4}$ -8-57-26W.). They are practically clays of a bluish grey color, underlying the Dakota sandstone, and under heavy overburden of the sandstone and Pleistocene deposits, except on a low river flat immediately below Alex. Fraser's farm house, where there is probably not more than three feet of overburden. The clay softens at Cone 20 (2,786°F), is a good semi-refractory material, and was considered by Keele to be the most useful clay so far discovered in Manitoba. There

are altogether several exposures of this clay shale on the Swan river within a distance of 2 miles down stream and 1 mile up stream from this point; but nowhere as accessible as on the river flat at Fraser's house. These shales may be of value for refractory materials in connection with smelting operations in Northern Manitoba.

Local Conditions of the Clay Industry.—

During the years of building expansion prior to 1913, brick of any quality was in demand, and the main output was common brick, manufactured by the soft mud process, and burnt in scove kilns. Nearly all the face brick of superior quality was imported at high prices. With the revival of building, and the slowly growing demand for brick, it is increasingly necessary to supply, if possible, not only the common brick which the plants operating in the province can supply, but also the much higher priced face brick, which has been imported from Fort William, St. Louis, Minneapolis, Moose Jaw, Medicine Hat and elsewhere. While a considerable part of this imported material has been smooth-faced dry press brick, there has been a growing demand for wire-cut tapestry brick which is capable of strikingly decorative effect. The colors which have been most sought after in face brick have been dark red to chocolate brown or brownish green. It is this market that efforts are now being made to supply, to some extent successfully, within the province. At the Alsip plant, by admixture of a loamy clay from Firdale (upper 10 feet) with the surface clay (upper 3 feet) from their own yards, a tapestry brick (stiff mud) of shades of red, brown and green is being produced which is used as a face brick in nine of the apartment blocks now being built in Winnipeg. This is a notable advance in meeting the competition of outside brick. At Edrans, where a dry-press brick of fairly deep color has been produced, a stiff mud process plant is now installed to produce a tapestry brick. Some very effective flashed brick has been got here; and with careful screening of pebbles, this plant should also supply part of the face brick demand which has previously been met from outside the province. Burning has been done in three downdraft- rectangular kilns and two scove kilns. At Sidney, where a supply of brick is on hand, and no burning has been done during the past two seasons, nor this season, an up-to-date plant was erected to handle face brick and hollow tile by the stiff mud process. The color is a deep red to chocolate brown, and effective tapestry brick was produced. The sandy clay, which resembles the clay at Firdale and is lighter than that at Edrans, was operated to a depth of 12 feet below the overburden of 2 feet. Burning was done in 10 circular down-draft kilns. The capacity of these three plants is amply sufficient to meet all the present demands for tapestry brick in Winnipeg and the rest of the province, and in all probability the demands for several years to come. A grade of brick has not

been reached which compares in quality with some of the imported brick, but the price of the local brick is so much less that the market for the local product should increase, and the success of experimentation thus far achieved gives encouragement to further trial with our clays.

It is recognized by the manufacturers that the face brick industry does not in itself have a sufficient local market. The main volume of the brick business (90% or more) is in common brick. The face brick business in this province will probably tend to become an adjunct to the manufacture of common brick, with the use, if necessary, of mixtures of clays, or clays and shales, for face brick or hollow tile. As already stated, the common brick from the Red river valley burns light buff to grey, and is, for common brick, unusually refractory. Various grades of red are obtained from clays on the Manitoba escarpment and on the sand hills; but some of these clays are lacking in plasticity and mixing with the more plastic clays improve the qualities of both types. There is also a field for experimentation in the under clays (40 feet or more in thickness) in the Red river valley, which cannot be handled, owing to abnormal plasticity, in the raw, but if pre-heated to 300°C, are easily worked and burn to a pleasing salmon red color. At Edrans, a dry-press brick is made from the surface clay (upper 5 feet), and fairly deep red uniform colors, as well as brown flashed faces are obtained. At Leary, a bright red dry-press brick was made from the carbonaceous Niobrara shales, burnt in a down-draft kiln; the plant has not been in operation for the past eight years. Great care was necessary in burning, to avoid puffing, and to ensure that the carbonaceous material was fully oxidised, otherwise a black core was left. When well burnt, a good brick was obtained. Part of the demand for smooth-face brick has now been taken care of by tapestry brick.

Hollow brick, hollow tile, and drainpipe are produced at the stiff mud plants in the province. Sewer piping was manufactured for a short time at Carman by admixture of Niobrara and Pierre shales, and the brick plant in North Winnipeg (Winnipeg Clay Products, Ltd.) was built to handle vitrified brick as well as face brick or hollow tile, from a mixture of similar shales. No clay products of higher grade, such as fire brick or pottery ware, have been produced, and for this purpose no clays are available of the grade of some of the clays of southern Saskatchewan. The most refractory clay which is available in quantity is a clay horizon associated with the Dakota sandstone in the Swan river valley, eight miles down stream from the town of Swan River. This may be of value for furnace brick if smelting operations are initiated in the copper areas of northern Manitoba.

To summarise, the present demand for common brick is being met by five brickworks, producing white, buff, or pale red bricks

from surface clays by the soft mud process, viz.: Alsips' and Marion's in the Winnipeg area; Whitemouth, (McCutcheon); Portage la Prairie (Snyder); Gilbert Plains (Snyder). A red dry-press brick is produced at Edrans, also from surface clay; while tapestry brick is now manufactured at Alsip's, (mixture of Winnipeg and Firdale surface clays), and Edrans (surface clay), and plants for the manufacture of tapestry brick are equipped at Sidney (surface clay) and North Winnipeg (mixture of Cretaceous shales from Morden and La Riviere). The use of reinforced concrete and stone in the larger business buildings, and of stucco finish in bungalow and cottage residences, has for the time relegated brick to apartment blocks, schools and similar buildings; the demand for brick has consequently not kept pace with building expansion. Considerable progress has been made in meeting the demand for tapestry brick by the mixing of clays in the province, and further progress is possible, particularly by pre-heating the under clays of the Red river valley, which are too plastic in the natural state, and of which a depth of 40 feet of uniform material is available. For sewer pipe and vitrified brick, mixtures of Cretaceous shales must be used; and a fairly refractory brick may be obtained from the Dakota shale horizon in the Swan river valley. Refractory clays for firebrick and pottery ware, such as occur in southern Saskatchewan, have not been found in Manitoba, with the exception of what appears to be a limited occurrence of kaolin on Little Deer Island, lake Winnipeg. Ample raw material is available for the common brick market, and the indications are that all but the most exclusive demands in face brick will be supplied from sources within the province as well.

See also:

Clay and Shale Deposits of the Western Provinces, (Memoir No. 66, part V, 1912, G. S. C.), by Joseph Keele.

Preliminary Report on the Clay and Shale Deposits of the Western Provinces (Memoir No. 24, G. S. C.), by H. Ries and J. Keele.

Report on the Clay and Shale Deposits of the Western Provinces, (Memoir No. 25, 1914, G. S. C.), by H. Ries and J. Keele.

Clays of the lake Agassiz Basin (Trans. of the Royal Soc. of Can. XVIII, Sect. IV, 1924, pages 9-30), by R. C. Wallace and J. E. Maynard.

DOLOMITE

To a large extent, the region between lake Winnipeg on the east and lakes Manitoba and Winnipegosis on the west is underlain by dolomites of Silurian age. Similar rocks underlie an area of over 4,000 square miles extent in the vicinity of Port Nelson, but are exposed on the Nelson river only.

The following table indicates the sequence of the Silurian in southern Manitoba, the principal exposures, and the localities where development has taken place.

Formation and Estimated Thickness	Best Exposures	Where Quarried at Any Time
Leperditia hisingeri zone, 100'	Inwood, Broad Valley, on the C.N.R. from Camper northwards to old Gypsumville, along the Saskatchewan river, at Cumberland Lake, Cedar Lake, Cross Lake.	Inwood, Broad Valley, Fairford, Old Gypsumville.
Gypsum beds, 150'		
Virgiana decussata zone, 135'	Stonewall, Gunton, Grand Rapids on the Saskatchewan river, Fisher Branch.	Stonewall, Gunton.

The stone is usually fine grained, tough, hard and often cavernous. Quarry beds of the Virgiana decussata zone consist of a harsh dolomite, buff to grey in color and cavernous. On the other hand a very fine-grained, almost lithographic type is found in the Leperditia hisingeri zone.

A brief description of the quarry properties follows:

Stonewall—

The town of Stonewall is situated on a slight elevation and, as the overburden is slight, quarrying is not difficult. Development has taken place immediately north and east of the town. North and east of the quarry belt, the country falls off, due to erosion of the upper and more valuable beds. To the south and west, operations must eventually stop because of the presence of the town and the increasingly heavy overburden.

The Winnipeg Supply and Fuel Co. is the only firm now operating, their holdings being on Sec. 36, Tp. 13, Rge. 1E, and on Sec. 30, Tp. 13, Rge. 2E. Stone is extracted from two quarries, No. 1 on the west side of the Winnipeg Beach highway and No. 2 on the east side. As both have been worked for a considerable period, extensive openings have been made. Recent workings have been on the west face of No. 2 quarry and the east face of No. 1 quarry.

The stone has a high magnesia content—in some cases higher than that required for the theoretical composition of dolomite. It is very hard, tough, and often cavernous.

The following section taken at the west face of No. 2 quarry is fairly typical, though there is less of the upper stone at the No. 1 quarry.

5'-7'	Overburden
2' 6"	Shattered stone. Usually contains too much clay to be of value.
10'	Quarry beds. White, fine grained, mottled. Upper beds, 2" and over. Lower beds, 2' and under, and have been used as a building stone.

SUB-FLOOR

3' Hard beds. Hard, uniform, fine
grained, splintery.

FLOOR

1'.....Red bed. Hard, nodular, shaly.

The 10 feet quarry beds make a very white lime, slow setting owing to its high magnesia content, but setting hard. No lime of similar quality has been produced from other districts. Locally the thicker beds have been used for building purposes. In the rough the stone has a very fine appearance and seems very resistant to weathering. The 3 feet hard beds are used for crushed stone only.

The following analyses may be taken as fairly typical:

	I	II	III
	Percent	Percent	Percent
CaCO ₃	53.51	55.05	56.25
MgCO ₃	42.91	42.75	42.17
Al ₂ O ₃ +Fe ₂ O ₃	1.00	0.32	0.12
SiO ₂	1.60	0.50	0.50

I —No. 1 quarry, 6' quarry beds.

II —No. 2 quarry, 8' beds, N.E. face.

III—No. 2 quarry, 8' beds, S.W. face.

Quarrying operations are simple. The overburden is removed by a ½-yd. electric shovel. At No. 2 quarry the stone is blown down to the floor, then loaded into horse-drawn dump carts and hauled either to the kilns or to the crusher. At No. 1 the stone is loaded into skips on horse drawn trams.

The plant consists of a battery of 3 kilns at No. 1 quarry and 2 kilns and a crusher at No. 2 quarry. Electricity is used throughout. The maximum production is about 2,400 bushels of lime per day.

Gunton—

Near Gunton, on Sec. 28, Tp. 15, Rge. 2E, fairly extensive operations were carried on for a number of years. Nothing has been done during the last decade, however.

The stone, though not similar in character to that at Stonewall is probably of almost the same horizon. It was used only for crushing and for rubble. A large quantity is still readily available. The formation is strongly jointed, the more important joints striking at N15°E with a secondary system at E15°S. Splendidly developed glacial grooves and striae are apparent on the surface.

The quarries are located a short distance south of the village. No. 1 quarry, immediately east of the C.P.R. track, is about 500' long, from 200 to 300' wide and presents a maximum face of 26' 4". At the north end the face is 5' less owing to removal of the upper beds by erosion.

A section taken at the south end is given below:

2'	Stripping.
10' 7"	Pitted, fine-grained, crystalline. Mot- tling consists of small dark brown patches in a cream-colored base. Beds average 6" in thickness.

SUB-FLOOR

6"	Nodular bed. More or less red. Re- sembles the 1' nodular red bed at Stonewall.
15'	Fine-grained, hard, wavy stratification. Heavily bedded, up to 2' 6", but minor partings reduce to 8" or 10" at most. Beds are mainly yellow.

FLOOR

At the north end of the quarry the upper 2 feet of the section are absent. The stripping seldom exceeds 4 feet.

EQUIPMENT—

- 3 donkey engines
- 2 derricks
- 1 power house
- 1 crusher.

Immediately west of this quarry and on the other side of the track is No. 2 quarry, an opening approximately 700 feet long, 250 feet wide and with a face of 24 feet at the southeast end. At the south end 8 feet of stone overlies the red nodular bed, but at the north end only 4 feet.

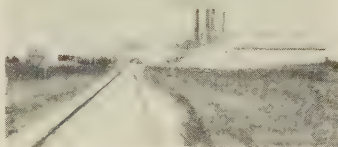
EQUIPMENT—

- 1 donkey engine
- 2 derricks
- 1 boiler house
- 1 crusher

No. 3 quarry is about a quarter-mile north of No. 2. It is a triangular-shaped opening, approximately 200 feet by 400 feet by 500 feet and presents a maximum face of approximately 21



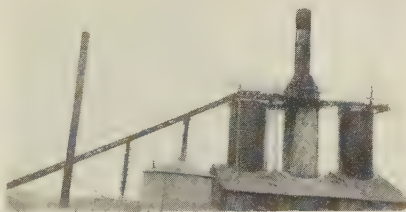
1



2



3



4



5

PLATE III.

1. Steam Shovel, Manitoba Gypsum Co., Gypsumville.
2. Canada Cement Co., Tuxedo.
3. Western Stone Co., quarry and mill, Garson.
4. Battery of lime kilns, Spearhill.
5. Gypsum quarry, Gypsumville.

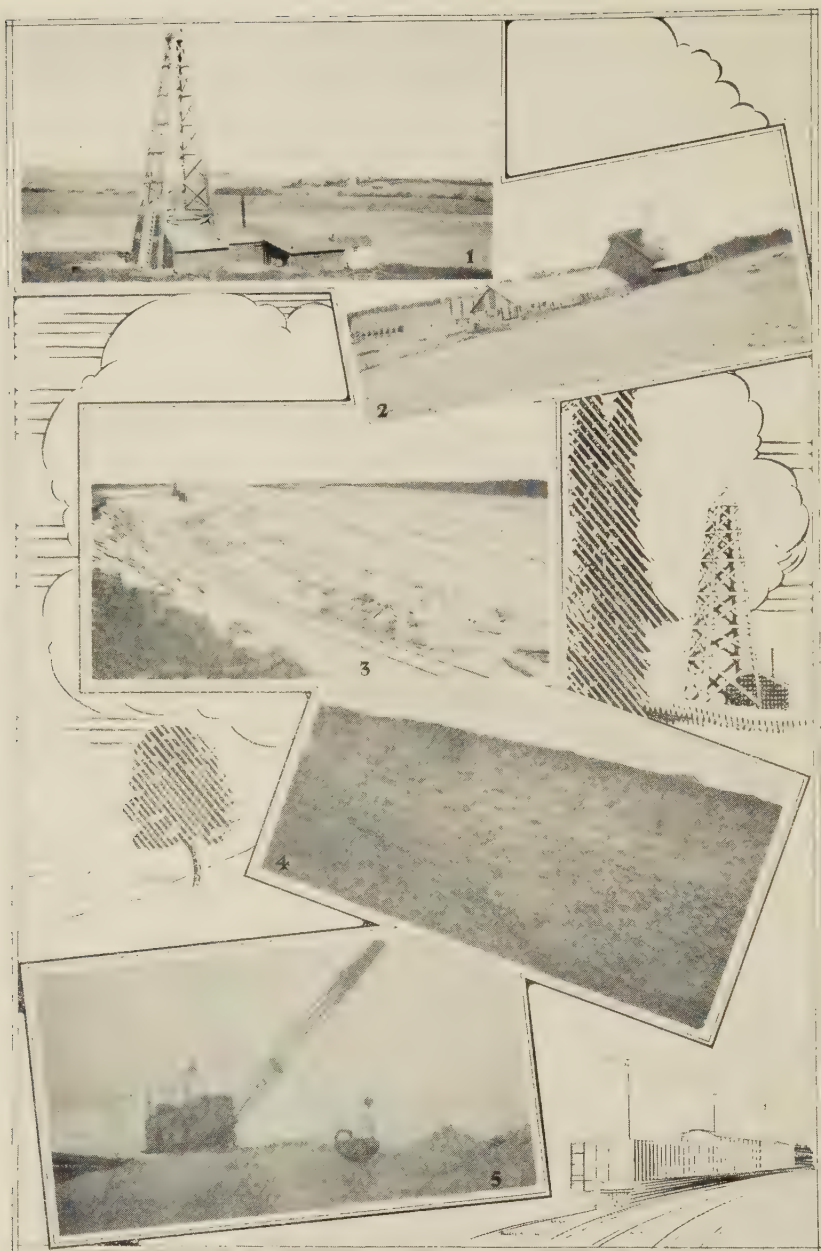


PLATE IV.

1. Derrick drilling for oil, southwest of Treherne, looking northwest. N.E. $\frac{1}{4}$, Sec. 28-7-10W.
2. Press brick plant at Edrans, looking northeast across clay pit.
3. Gravel pit, Woodlands, showing edge of pit.
4. Face of gravel quarry, Great West Sand and Gravel Co., Bird's Hill, looking east.
5. Steam shovel, Greater Winnipeg Water District gravel pit, Mile 80.

feet. At the south end the red nodular bed is overlain by four feet of stone, but at the north end it is almost at the surface.

Inwood—

Some years ago a small quarry was worked $1\frac{1}{2}$ miles N.W. of the village of Inwood. It is situated on the N.W. $\frac{1}{4}$ of Sec. 10, Tp. 18, Rge. 1W. The overburden is very light, in places absent, over a considerable area. The rock of the upper 6 feet is rough, variable in texture, yellowish and fairly distinctly mottled. The 16 inch top bed presents possibilities for use as a building stone. Below the upper stone a thin-bedded, white, exceedingly fine-grained and splintery dolomite possessing a conchoidal fracture has been reached.

Operations were on a small scale, the opening not being more than 40 by 30 feet, and from 5 to 8 feet deep. Apparently the stone was used only for lime burning.

Broad Valley—

On the middle of the S.E. $\frac{1}{4}$ of Sec. 22, Tp. 23, Rge. 2W, quarrying has been carried on in a very small way, though not in recent years. This location is 1 mile north of the village of Broad Valley and is immediately east of the Hodgson branch of the C.N.R. A low escarpment, striking about east and west, occurs at this point. Operations seem to have taken place mainly on the face of this escarpment, although there are two shallow trenches about 300 feet to the south. Quite an extensive area has little or no overburden.

The section appears to be:

	No overburden.
1' 9"	Fine-grained, crystalline, whitish-yellow, fairly soft. Parted in places.
2' 9"	Same as top bed. Parts in 3 in places.
5' 4"	Thin-bedded, white, exceedingly fine-grained, conchoidal fracture. Similar to lower stone at Inwood.
	Not exposed.

Attempts were made to use the stone for interior use as a decorative material. All equipment has been removed.

Fairford—

A little dolomite has been extracted from pits for local use. It is not of sufficient thickness to be used except for rubble.

Old Gypsumville—

A small amount of stone has been quarried on a ridge 2 miles west of Old Gypsumville. A great quantity of a rather variable but fairly thick dolomite is available, although no high grade building stone has been found.

Hudson Bay Railway Area—

A little quarrying has been done in the vicinity of Cormorant lake in connection with the construction of the railway. The stone is nodular, extremely cavernous and is thought to be of Silurian age. Stripping is very slight. While some of the beds are fairly thick, they are marred by partings. The rock would be of little use as a building stone.

SEE ALSO—

Preliminary Report on the Limestones and the Lime Industry of Manitoba, (Mines Branch, Dept. of Mines, Ottawa, 1905), by J. W. Wells.

The Silurian and Devonian Section of Western Manitoba, (XXI, Summary Report of the Geological Survey, Dept. of Mines, for the calendar year 1912, pages 247-258), by E. M. Kindle.

Pseudobrecciation in Ordovician Limestone in Manitoba, (The Journal of Geology, Vol. XXI, No. 5, July-August, 1913, pages 402-421), by R. C. Wallace.

GYPSUM

Although gypsum has been found at many localities in the province, it has been exploited only at Gypsumville where large deposits occur northwest of the narrows of lake St. Martin, "The district in which gypsum outcrops are known to occur, covers an area about seven miles north and south, and eight miles east and west, being located principally in Tp. 33, Rge. 8; Tp. 33, Rge. 9; N $\frac{1}{2}$ Tp. 32, Reg. 8; N $\frac{1}{2}$ Tp. 32, Rge. 9; all west of the principal meridian." (*) Approximately 130,000,000 tons are actually exposed.

In the main, these outcrops are on low ridges of gypsum which rise from 20 to 40 feet above the surrounding swampy country and which have in general a north-south trend. Small knolls of gypsum are not infrequent. The surface is pitted by funnel-shaped sink-holes. The overburden is slight on the higher portions of the deposits, but a thickness of 3 or 4 feet on the bottom of the sink-holes is common.

The gypsum occurs in beds which vary in thickness from $\frac{1}{4}$ inch to 3 feet and which are often separated by a film of argillaceous material. Locally they dip to the north. Two varieties of gypsum are common; the earthy gypsum rock in beds seldom less than 3 inches thick, and the fibrous satin-spar, usually in beds from $\frac{1}{4}$ inch to 1 inch in thickness. Anhydrite is mixed with the gypsum, the percentage increasing with depth. A striking feature is the development of numerous small anticlinal arches probably due to the increase in volume caused by the

(*) Gypsum in Canada, Its Occurrence, Exploitation and Technology (Vo. 245, Canadian Dept. of Mines, Mines Branch), by L. H. Cole.

transformation of anhydrite to gypsum. The irregular topographical features can be traced, in part, to the major folding of the gypsum beds.

The gypsum was laid down in Upper Silurian times, apparently in restricted inland seas, subjected to excessive evaporation. North of lake St. Martin and Partridge Crop lake, there are several outcrops of igneous rocks of pre-Cambrian age. These outcrops represent the tops of hills or a high plateau that rose at least 800 feet above the average level of the pre-Cambrian surface. It seems not improbable that this topographical feature formed a barrier which caused the restriction of a sea in which the salts became highly concentrated and were laid down to a much greater extent than elsewhere. In southern Manitoba there does not appear to have been any such restriction, consequently the gypsum beds are not so thick, though apparently quite widespread. In all the occurrences considerable thicknesses of red clay or shale underlie the gypsum beds.

History of Development—

Development started in 1901, when the Manitoba Union Mining Co. staked out some of the gypsum deposits and erected a small mill at Old Gypsumville on lake Manitoba, 12 miles southwest of the present village. At that time there was no rail connection and the calcined gypsum was shipped down the lake to Delta. Later a track was laid from the quarries to the lake so that the gypsum could be freighted to the mill all the year. In 1904 the Manitoba Gypsum Co. purchased the Manitoba Union Mining Co. The mill burned down in 1906 and a new mill was then put up at Winnipeg. The raw gypsum was then shipped by barge down the lake to Delta, thence by rail to Winnipeg. In 1910 the Oak Point branch of the Canadian Northern Railway was extended to Gypsumville and from that time shipments have been by rail only.

Operations are now carried on only by the Manitoba Gypsum Co. whose principal holdings are on Sections 26 and 35, Tp. 32, Rge. 9W., and on Sec. 3, Tp. 33, Rge. 8W. (Elephant Hill). The main quarry is on the northeast quarter of Sec. 26, Tp. 32, Rge. 9W., and has been driven into the ridges immediately north of the village. It is an "L" shaped opening, the south arm being approximately 800 feet long and 150 feet wide and the west arm of about the same dimensions. The north face of the west arm is now being worked, the height varying from 6 to 20 feet, probably averaging 10 feet. The gypsum though rather dirty has very little anhydrite in it.

Quarrying—

Quarry methods are simple. After clearing away the underbrush and removing the overburden by scrapers, a row of four

holes, 4 feet apart and 4 feet back from the face is put down to the level of the quarry floor. A comparatively light charge of 60% dynamite suffices to break up the face. The broken gypsum is then scooped up by a large steam shovel and loaded directly into railway dump cars. Any excessively large lumps are reduced in size by men in the cars.

Fifteen men are employed the year round. Shipments average 160 cars per month during the summer. The total output for 1926 amounted to 35,172 tons. This figure was nearly doubled prior to the war when building was very active.

More or less continuous pumping is necessary to keep the quarry dry. A more efficient drainage system to lake St. Martin, which would permit considerably deeper quarrying is a likely development of the future.

EQUIPMENT—

- 1 wood-burning steam shovel
- 1 wood-burning locomotive
- 1 pumphouse

Immediately to the west is the company's old quarry. It measures approximately 1,500 feet in a north and south direction, up to 400 feet east and west and is up to 25 feet in depth. The gypsum was very clean here but contained a rather high percentage of anhydrite. Work was discontinued when a zone on the west face, especially rich in anhydrite, was struck. Indications are, however, that this zone is of limited extent. Two drill holes put down in this quarry showed a vertical thickness of 150 feet of gypsum and anhydrite above the basal red shales.

On Section 3, Tp. 33, Rge. 8W., some 6 miles to the east and north is the deposit known as Elephant Hill. Here a 15 foot bed of selenite, the pure crystalline variety of gypsum, is interstratified with massive gypsum. On account of its purity it is used for plaster-of-paris manufacture. Approximately 40 carloads are teamed out every winter.

Anhydrite—

Anhydrite occurs in the form of separate deposits as well as associated with the gypsum. On Sections 3 and 10, Tp. 33, Rge. 8W., diamond drilling has proven a body of anhydrite at least 100 feet thick. Tyrrell (*) described a hill on the north-east quarter of Sec. 31, Tp. 32, Rge. 8W., on which a thickness of 22 feet of anhydrite had been exposed. There has been no production from these deposits, although the polished stone shows a surface rather similar to that of fine-grained marble and might be of value for ornamental purposes in interior work.

(*) Gypsum Deposits in Northern Manitoba (Can. Rec. of Science, Vol. III, April 1889), by J. B. Tyrrell.

Other Deposits in Northern Manitoba—

Near Fairford, 15 miles south of Gypsumville, gypsum was struck at a depth of 75 feet in a well. At Ashern, 30 miles south of Fairford, a 2 foot bed was encountered at a depth of 40 feet. A bore-hole which was put down on the Vermilion river, 75 miles to the southwest, is reported to have struck a 15 foot gypsum bed at a depth of 550 feet. This deposit, however, is thought to belong to the Devonian series.

The following tables indicate the depths and thickness of gypsum occurrences in southern and western Manitoba.

Southern Manitoba—

Locality	Gypsum encountered at a Depth of	Thickness of Gypsum	Remarks
17 miles east of Dominion City.....	260'	45'	5 drill holes were sunk. Gypsum was also encountered at irregular intervals from 325' to 450'. Very pure and white.
Arnaud.....	175'	25'	Encountered in a well.
St. Elizabeth.....	153'	27'	Encountered in a well.
St. Charles.....	40'		Encountered in a well.
(Near Wpg.)			
Charleswood.....	25'	5'	Encountered in a well.

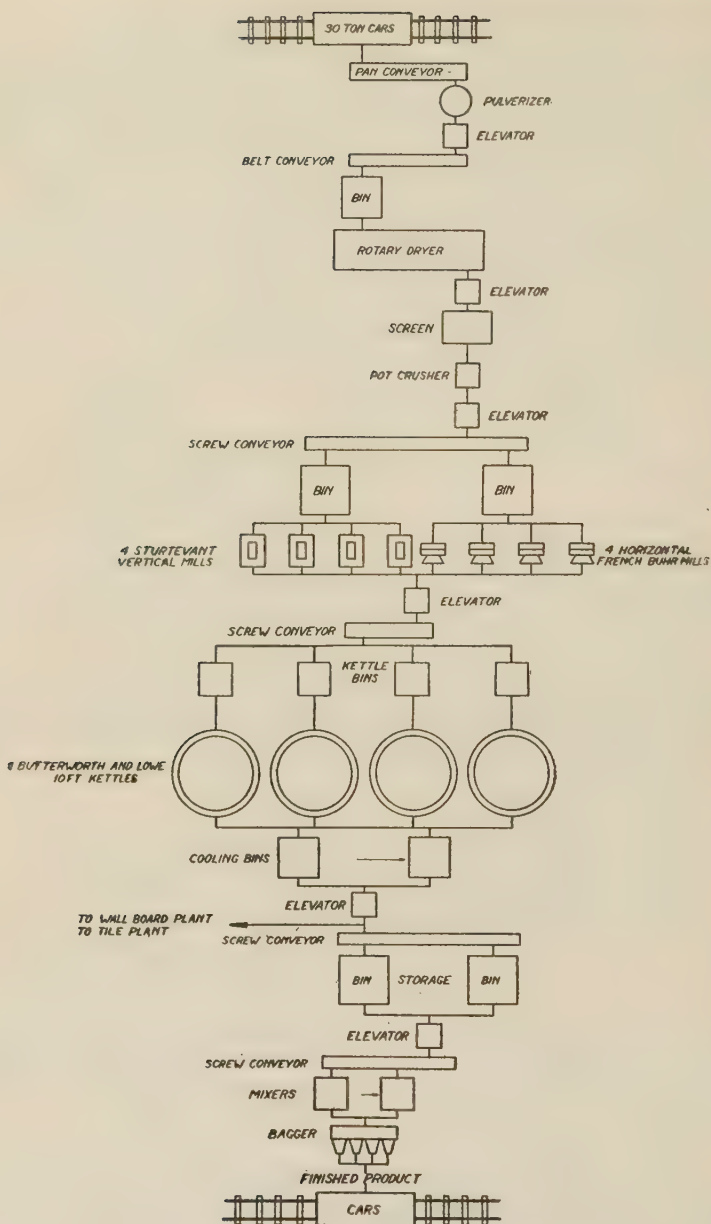
This data would seem to indicate that a gypsum bed of variable thickness is developed in the district from Winnipeg southward to the International boundary line.

Western Manitoba—

Locality	Gypsum encountered at a Depth of	Thickness of Gypsum	Remarks
Leifur.....	10'	10'	Found by exploratory drilling to extend over several sections of land.
Rathwell.....	960'	62'	62' of gypsum and red clay. Some anhydrite.
Neepawa.....	1100'		Data of thickness not available.
Gladstone.....	201'	50'	50' of limestone and gypsum; probably Devonian.

None of these deposits could produce gypsum in competition with the Manitoba Gypsum Company's quarries at Gypsumville.

The boundary between the *Virgiana decussata* zone and the gypsum beds is drawn, in the light of the evidence now collected, southeastwards from the narrows of lake St. Martin



Flow Sheet, MANITOBA GYPSUM COMPANY LTD., WINNIPEG, CANADA

Fig. 7—Flow Sheet, Manitoba Gypsum Co's Mill, Winnipeg

to a point a few miles south of Fisher Branch, thence southward along a line lying east of Broad Valley and Inwood and west of Stonewall and Winnipeg, thence southeastward across the Red river to the 49th parallel, crossing the line somewhat east of Stuartburn. North of lake St. Martin the position of the line is somewhat doubtful, but may be drawn provisionally from a point six miles east of Gypsum lake, to "Roche Rouge", on the Saskatchewan river, between Cross lake and the Grand Rapids, the line passing east of Pickerel lake. (*)

Markets, Manufacturing—

The mill of the Manitoba Gypsum Company is situated in the western outskirts of Winnipeg. During the summer months, between 100 and 125 men are employed and about 300 tons of gypsum handled daily. Approximately two-thirds of the gypsum is made into hard-wall plasters of various kinds, the remainder of the gypsum being required for wall-board, partition tile, roof slabs, Keene's cement, land plaster, casting plaster, plaster of paris, etc. In addition, whiting, whitewash, lime hydrate and retarder are manufactured. The entire requirements of the Canadian West from the head of the lakes to British Columbia are met by this plant.

The accompanying flow sheet indicates the process followed, but a short description may be of interest. After unloading, the crude gypsum is pulverized to one-half inch or less, then conveyed to the rotary calciner where it is heated to 170°F. This drives off uncombined moisture and effects partial calcination. The hot gypsum is next ground to between 80 and 100 mesh in the eight grinding mills, then dumped into the four big kettles where it is heated at 320°F. for approximately one and a half hours, not more than six percent water remaining. The remainder of the process varies according to the product manufactured. For hard-wall plasters, hair or wood-fibre and retarder are added in the mixers; packing in bags and weighing being accomplished automatically in one operation. Wall-board is made by mixing plaster, wood-shavings and water, spreading between sheets of heavy paper and baking in kilns at 170°F to 180°F. for six or seven hours. Nearly 8,000,000 feet was manufactured in 1926.

LIME

Lime is produced at three points in Manitoba, viz.: at Spearhill, by the Moosehorn Lime Co. (Winnipeg Supply and Fuel Co.); at Stonewall by the Winnipeg Supply and Fuel Co.; and at Garson by Gillis Quarries, Ltd. As the rock is of different character at

(*) Gypsum and Brines in Manitoba. (Summary Report of the Geological Survey, Dept. of Mines, 1914), by R. C. Wallace.

Gypsum and Salt in Manitoba (XVII, Summary Report of the Geological Survey, Dept. of Mines, 1913, by A. McLean and R. C. Wallace.

Gypsum and Anhydrite in Genetic Relationship (Geol. Mag., Decade VI, Vol. I, June, 1914), by R. C. Wallace.

each of these localities, three different types of lime are produced. The Spearhill lime is very high in calcium, the Garson less high, and the Stonewall lime very high in magnesia.

Spearhill lime is used mainly for chemical purposes, the largest consumers being sulphate paper mills. It is also in demand by the oil refining industry and in the manufacture of bleaching powder. Two Winnipeg plants use this lime for making sand-lime bricks.

Stonewall lime is well adapted to the sulphite pulp process, and is shipped in considerable quantities for this use. As a finishing lime for plaster work, and also for mortar, it has a high reputation.

Lime is produced intermittently at Garson, as a by-product to the quarrying of building stone. It is sold chiefly to the building industry.

The following analyses have been kindly supplied by the Winnipeg Supply and Fuel Co.

	I	II
	Percent	Percent
Calcium Oxide.....	96.11	57.22
Magnesium Oxide.....	1.39	41.12
Silica.....	1.82	.53
Iron and Aluminum Oxides.....	0.68	1.13
	100.00	100.00

I—Spearhill lime.

II—Stonewall lime.

SEE ALSO—

Preliminary Report on the Limestone and the Lime Industry of Manitoba, (Mines Branch, Dept. of Mines, Ottawa, 1905), by J. W. Wells.

LIMESTONE

Sediments of Palaeozoic age underlie about one quarter of the area of Manitoba. Since they were laid down under marine conditions, it is to be expected that many occurrences of limestone are known. Most of these are of geological interest only, as they are either covered too deeply or are unsuitable for economic purposes. Many, however, can be worked profitably, providing the demand warrants.

Limestone is required for the manufacture of lime, wood pulp, cement, whiting; and is also used in great quantities for rubble, road material, building stone and concrete work.

Ordovician Limestones—

The following table indicates the sequence of the Ordovician in Manitoba, the more important exposures, and the localities where quarrying has taken place of recent years.

Formation	More Important Exposures	Where Exploited
Stony Mountain shales, 190 feet	Stony Mountain, Little Stony Mountain, east of Fisher Branch.	Stony Mountain, Little Stony Mountain and vicinity.
Upper Mottled limestone, 130 feet	On west shore of lake Winnipeg, north of mouth of Saskatchewan river, East Selkirk Garson, Lower Fort Garry, St. Andrews Locks, East of Fisher Branch.	East Selkirk, Garson, Lower Fort Garry, St. Andrews Locks.
Cat Head limestone 70 feet	Cat Head, McBeth point, Fir-mont island, Howell point, Rob-inson point, all on lake Winnipeg	
Lower Mottled lime-stone 70 feet	Grindstone point, Bull Head, Dog Head, Black Bear island, Tamarack island, Jack Head island, and on Hecla (Big) island, all on lake Winnipeg.	Hecla island.
Winnipeg sandstone, 100 feet		

A brief description of the quarries follows:

Hecla island—

The quarry was operated by the Lake Winnipeg Shipping Company who held the northwest quarter of Sec. 28, Tp. 25, Rge. 6E. Here, on the east shore of the island, a cliff of limestone one half mile in length faces the lake. The overburden increases to the southwest, the dip being away from the lake. The stone is high in magnesium, hard and characteristically mottled. The thinness of the bedding precludes any use for it except as rubble or crushed stone.

Analysis made by D. J. Birse, University of Manitoba:

	Percent
CaCO ₃	76.21
MgCO ₃	16.10
SiO ₂	6.21
Al ₂ O ₃ +Fe ₂ O ₃	1.33
	99.85

Garson—East Selkirk—

At Garson one of the best building stones in Canada is quarried. It lies on the east end of a ridge which extends west-ward to East Selkirk. The stone and quarrying operations are described under Building Stone. It has been estimated that there

is a thickness of over 30 feet of available building stone under an overburden of from nine to thirteen feet. Future development should be on a large scale.

Prior to the war a considerable amount of lime was burned, but of recent years the production has been small. At present two kilns at the Gillis quarry are operated intermittently, waste stone being burned. The 1926 output amounted to 20,304 bushels.

All three of the quarry companies make small shipments of rip rap and rubble when the demand warrants.

Like most of the Palaeozoic limestones of Manitoba it is strikingly mottled. An analysis of an average sample from the old Gunn's quarry (now operated by the Western Stone Co.) and typical analyses of the light and dark parts of the mottling, follow:

	Percent		Light Colored Percent	Dark Colored Percent
Moisture.....	0.10	SiO ₂	1.56	1.56
Insoluble material.....	1.08	Total iron as Fe ₂ O ₃	0.16	1.94
Al ₂ O ₃ + Fe ₂ O ₃	0.60	(FeO.....	0.12	0.45)
CaCO ₃	82.12	Al ₂ O ₃	0.06	2.27
MgCO ₃	16.25	CaCO ₃	94.02	71.03
	100.25	MgCO ₃	4.33	23.35
	(*)		100.13	100.15
			(**)	(**)

It is more than 25 years since the quarries at East Selkirk produced any stone. The formation seems to have been more broken than at Garson. While essentially the same, the stone is a little softer and a little lighter in color. It was employed to a large extent in Winnipeg before the Garson stone came on the market.

Lower Fort Garry—St. Andrews Locks—

“At the Stone Fort, or Lower Fort Garry, an exposure of 8 to 10 feet of limestone, in horizontal beds is seen on the western bank (of the Red River), near the mouth of a small stream entering above the fort . . . This has long been quarried for making lime and building stone.” (***)

“Low shelving limestone crosses the river at St. Andrews, but very little is exposed, being covered for the most part by drift.” (***)

(*) Preliminary Report on Limestones and Lime Industry of Manitoba (Can. Dept. of Mines, Mines Branch, Report No. 7, 1905), by J. W. Wells.

(**) Pseudobrecciation in Ordovician Limestones in Manitoba. R. C. Wallace, *Journal of Geology*, Vol. XXI, No. 5.

(***) Report on the Geology of the West Shore and Islands of Lake Winnipeg (Part F. Annual Report 1898, G.S.C.) by D. B. Dowling.

Little can now be seen of these exposures, on account of the heavy overburden and talus which more or less completely covers them. The stone appears to be almost identical with that at Garson. Lower Fort Garry, and the Selkirk Asylum are examples of its use. That a considerable amount of lime was burned is attested by the remains of many small kilns along the river between the Fort and Lockport. There is no record of production in recent years.

Stony Mountain—

The City of Winnipeg owns 80 acres on the southwest quarter of Sec. 14, Tp. 13, Rge. 2E., and operates a quarry on it. The quarry has been opened along the north and west sides of the face of the escarpment to the north of the village of Stony Mountain and consists of an opening approximately 800 feet square and 14 feet in depth. Development of the south face has been halted by a road allowance. Only the east face can be worked.

As indicated by the uneven floor, there has been a slight local disturbance. In places, clay has been washed in from above, apparently wherever there has been minor folding. If possible these areas are avoided in quarrying as the stone is of poor quality. The beds seem to dip slightly to the east and north. Most of the beds are thin, but some of the lower ones are thick enough to be of potential value for building stone. The stone is dolomitic and is somewhat mottled. Beneath the 14 feet of quarry beds is 15 feet of yellow argillaceous limestone which has no economic value on account of its high clay content.

An electric shovel removes the overburden which averages 30 inches. In quarrying, holes up to 18 feet in depth are sunk 4 feet back from the face and 3 or 4 feet apart; 60 percent and occasionally 80% dynamite is used as explosive and the whole face blown down on the floor. The rock is then loaded into cable-hauled trams and sent to the electrically operated crusher where it is crushed and screened to one-and-one-half inch, half-inch, and dust.

The quarry supplies all the city streets with crushed stone, the half inch size being generally used. The C.P.R. purchases the one-and-one-half inch for station work, and occasionally takes rubble for fills, etc. The half inch is also in demand for tennis courts and stucco work.

Production costs are low as the quarry is well situated, completely electrified, and the stone is easy to recover. One hundred men are employed during the busy season. For the past several

winters, work has been carried on to relieve the unemployment situation in Winnipeg.

QUARRY EQUIPMENT—

- 1 $\frac{3}{4}$ yd. electric shovel
- 1 portable electric air compressor
- 2 tripod drills
- 1 jackhammer
- tram cars
- 40 (approx.) railway cars. All stone for the City's work is shipped in these cars.

CRUSHING PLANT EQUIPMENT—

- 1 No. 7 $\frac{1}{2}$ gyratory crusher
- 2 No. 3 gyratory crushers
- 2 screens, 40''x 12' and 40''x 16'
- 1 elevator
- 1 150 h.p. electric motor
- 1 50 h.p. electric motor
- 1 30 h.p. electric motor

Production, ten 34 yard carloads of crushed stone daily, (July, 1927).

Immediately to the south of the road allowance is the old Gunn quarry, from which stone of similar quality was extracted many years ago. The approximate dimensions of the opening are, 1,500 feet east and west, 1,000 feet north and south and 12 feet deep. Analyses of the upper and lower stone follow:

	Upper Stone Percent	Lower Stone Percent
Moisture.....	0.05	0.05
Insoluble.....	11.65	5.10
Fe ₂ O ₃ + Al ₂ O ₃	1.40	1.00
CaCO ₃	48.11	51.08
MgCO ₃	37.95	41.90
SO ₃	0.13	0.13
Undetermined.....	0.71	0.74
	100.00(*)	100.00(*)

Little Stony Mountain and Vicinity—

At one time the City of Winnipeg operated a quarry on the S.W. $\frac{1}{4}$ of Sec. 34, Tp. 11, Rge. 2E., this being on a low ridge six miles north of Winnipeg and known as Little Stony mountain. The quarry beds seem to be of the same horizon as those at Stony Mountain, but of less thickness. Many thousand tons of rubble and crushed stone were obtained, but the increasingly heavy

(*) Preliminary Report on Limestones and the Lime Industry of Manitoba (Can. Dept. of Mines Mines Branch, Report No. 7, 1905), by J. W. Wells.

overburden to the west finally stopped operations in 1905. Stone was taken off an area of two acres to a depth of 20 feet.

Immediately to the south, another quarry was worked on a smaller scale by private interests but was abandoned for the same reason as was the City's.

Considerable stone was removed from a quarry on the east half of the S.W. $\frac{1}{2}$ of Sec. 23, Tp. 12, Rge. 2E, three miles to the north of Little Stony Mountain. Immense quantities of stone are said to be still available beneath a stripping of from two to five feet.

Devonian Limestones—

Formation	More Important Exposures	Where Exploited
Manitoban limestone, 185 feet	On lake Winnipegosis at Snake island, southwest of Charlie island, mouth of Mossy river, west side of Pelican bay, west side of Swan lake, on Red Deer river, south shore of Red Deer lake.	Winnipegosis.
Winnipegosan dolomite, 168 feet	On lake Winnipegosis at White-eaves point, Salt point, Hill island, Pemmican island, and on the islands in Toutes Aides Bay, lake Manitoba.	No development on record.
Elm point limestone, 25 feet	Two miles north of Oak point and on shore of lake Manitoba, immediately north of Elm point, four miles northeast of Moosehorn, point Brabant and Graves point, lake Winnipegosis.	Oak point, Steep Rock, Spearhill (four miles northeast of Moosehorn).

No Devonian strata of sufficient thickness for building purposes have been discovered in Manitoba, but many exposures are very suitable for such uses as lime and cement manufacture. Most of those which have been developed belong to the Elm Point series. This formation is a pure limestone, seldom with less than 90 percent calcium carbonate and always more or less distinctly mottled.

Short descriptions of the quarries follow:

Spearhill—

The Moosehorn Lime Co., (Winnipeg Supply and Fuel Co.), hold the S.E. $\frac{1}{4}$ of Sec. 22, Tp. 27, Rge. 7W., and operate the quarry on it. The village of Spearhill immediately adjoins the quarry and is connected to Moosehorn by a spur line. The opening, measuring 1,000 feet in length, from 50 to 400 feet in

width and with an average depth of 11 feet, has been driven into a hill which has a distant escarpment to the east and northeast.

The bedding is fairly heavy, but minor partings render it impossible to obtain a thickness of more than 6 inches, 3 inches being the average. Portions of the rock carry a good deal of clay and must be discarded. Slight faulting with a displacement of less than one foot may be observed. A gentle dip prevails to the south and southwest. The joints apparently strike about east and west and are vertical. The stone is a hard, fine-grained, and characteristically mottled limestone.

Analyses made by the American Beet Sugar Company of East Grand Forks, N.D. follow:

	I	II
	Percent	Percent
CaCO_3	96.56	96.40
MgCO_3	1.42	1.24
SiO_2	1.58	1.95
$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	0.39	0.37
	99.95	99.96

Quarrying is simple. After removing a stripping of from one to six feet by pick and shovel, a row of holes is put down back from the face. A moderate charge of 60 percent dynamite suffices to blow the face down on the floor. The broken stone is loaded into small tram cars which run by gravity most of the way to the kilns.

This stone is in demand by pulp mills using the tower system for making their sulphite liquor. Some four cars per week are consigned to the Manitoba Pulp and Paper Co. Ltd., at Pine Falls and large shipments have been made to the head of the lakes.

MAIN PLANT EQUIPMENT—

- 4 kilns—capacity, 13 to 15 tons of lime each, per day
- 1 compressor
- air drills
- 1 complete stave plant for barrel manufacture
- machine shop
- Steam power plant

Steep Rock—

The Canada Cement Company's plant at Tuxedo is supplied with limestone by the Company's quarry at Steep Rock, 146 miles to the north. A section immediately east of lake Manitoba is held by the Company. Operations have been on a large scale, resulting in an opening approximately 1,700 feet long, 600 feet wide, and from 12 to 18 feet deep. The floor is of nearly the same level as the lake. A ditch at the east end drains into a lagoon connected with the lake.

The stone is thin-bedded, strikingly mottled, and almost flat-lying, though a dip of 3 to 6° to the west seems to prevail at the west end of the quarry. Vertical joints are common, the stronger ones striking E.25°S., and S.40°W. There are occasional areas where the beds seem to have been shattered and domed up. Pockets of clay are common in holes in the rock.

Quarrying—

After removing a few inches of stripping by horse scrapers, two gasoline-driven drilling machines are employed to put down a series of large holes to the floor level. A heavy charge of 60 percent dynamite so shatters the rock that it can be loaded by a large steam shovel into dump cars. A small locomotive hauls these cars to the crushing plant. The crushed stone is conveyed to large elevator bins and is loaded from them into open railway cars. From 3,000 to 4,000 tons per week are quarried during the season May to December and over 30 men are employed.

MAIN EQUIPMENT—

- 2 gasoline drills
- 1 1¼-yd. steam shovel
- 1 dinkey locomotive
- Dump cars
- Complete crushing plant including storage bins
- 1 360 h.p. Diesel electric power house
- 1 standby steam turbine powerhouse

Oak Point—

The quarry two and a half miles north of Oak Point station has not been operated since 1923. The property consists of the S.W. 40 acres of the S.W. ¼ of Sec. 18, Tp. 18, Rge. 4W, and is now owned by the Winnipeg Supply and Fuel Company. The quarry is a triangular-shaped opening of approximately one acre in extent, parts of it having a depth of at least 15 feet. As the floor is practically at the same level as lake Manitoba, more or less continuous pumping is necessary to render operations feasible. At present the quarry is filled with water to within 3 feet of the top.

The stone is very similar to that at Steep Rock and Spearhill. Analyses furnished by the Winnipeg Supply and Fuel Company follow:

	Percent	Percent
CaCO ₃	89.08	90.00
MgCO ₃	6.81	7.19
SiO ₂	2.90	2.10
Al ₂ O ₃ + Fe ₂ O ₃	1.10	0.50
	99.89	99.79

The beds are wavy and average 2 to 3 inches in thickness. A slight dip to the south seems to prevail. The joints are vertical, the main system striking at about N.40°W., and a secondary system at right angles. There is very little overburden over a considerable area.

The main plant equipment consisted of two kilns and a crusher, but one of the kilns has been dismantled recently and set up at Spearhill. Power was generated by steam.

Winnipegosis—

The Winnipeg Supply and Fuel Company own a property situated one and a quarter miles west of Winnipegosis and consisting of the N.W. $\frac{1}{4}$ of Sec. 9, Tp. 31, Rge. 18W. Quarrying on a small scale has been started recently by the Manitoba Gypsum Company, and an opening measuring 60 by 40 feet and with an average depth of 5 feet has been made.

Stone occurs under a very thin cover over an area of about 80 acres in extent. It is a very white, fine-grained, mottled and thin-bedded limestone and to date has been used only for the manufacture of whiting. Joints are fairly well developed, the main ones striking S.45°W. and dipping at about 70° to the southeast. An analysis follows: (*)

	Percent
Insoluble matter.....	1.20
Al ₂ O ₃ + Fe ₂ O ₃	0.40
CaO.....	53.09
MgO.....	1.01
Loss—carbonic acid, etc.....	43.45
	99.96

Some 400 tons were quarried during the winter of 1926-27 with the aid of a steam drill and a small boiler.

Eight miles southeast of Winnipegosis a similar occurrence has been worked, a wedge-shaped opening approximately 75 by 40 feet and 10 feet in depth having been made. The stone here is less definitely bedded.

MONUMENTAL AND ORNAMENTAL STONES

The stone in demand for monumental purposes in the province is granite. For this use granite is imported from British Columbia, Minnesota, Quebec, New Brunswick, from Scotland and, on occasion, from Germany. With the very large areas of exposed granite close to the railways in western Ontario and eastern Manitoba, it is not surprising that efforts are being made

(*) Report on the Building and Ornamental Stones of Canada (Vol. IV, 1916, Mines Branch, Dept. of Mines), by W. A. Parks.

to supply the market for the prairie provinces closer at hand. A grey granite is being introduced into Manitoba from Ignace, (C.P.R.) in western Ontario and a fine grained pink granite from Farlane, (C.N.R.) east of Minaki, also in western Ontario, has already found some use in Manitoba. The only granite in Manitoba territory which has been quarried for monumental purposes is the pegmatitic granite from Brookville, (M. 79, G.W. W.D.). The granite is intrusive into a grey sheared granite, and shows a coarse, pink felspar, which on polishing, gives a fine play of color. The stone requires to be carefully selected, and is of unusually large grain for the trade, but is undoubtedly handsome. A mill was installed at the property for sawing and polishing and work was continued until 1923, since when no stone has been shipped from the property. At the quarry, where a depth of 50 feet was reached, there is a width of 60 feet of effective red granite between the walls of the grey sheared granite on either side. A spur line is run in from the G.W.W.D. line at mile 79 northwards to the quarry a quarter of a mile.

In the earlier days of settlement in the Red River valley, mottled limestone of East Selkirk was used for monumental stone. This is a building stone of exceptional grade, and an excellent stone for interior decorative finish. It is not, however, a suitable stone for monumental purposes, as the color contrast is too great on a stone of small dimensions. It is not now being used for this purpose.

At Broad Valley, on the Inwood-Hodgson line (C.N.R.), a fine-grained lithographic dolomite of upper Silurian age is exposed. Carefully selected to avoid rock of a porous nature, this stone might be used for interior finish, as it takes on a fine marble-like polish. It has not yet been used for that purpose. An attempt was made in 1912 to use this stone, and a small quarry was opened up, but no further work has been done.

Northeast of Gypsumville (Sec. 3 and 10, Tp. 33, Rge. 8W.) a deposit of anhydrite (calcium sulphate) was drilled to a depth of 100 feet. The rock is of no value for exterior work, as it takes up water and disintegrates, but it might be of value as an interior finish, where well protected. It takes on a beautiful marble-like polish, in tints of bluish grey and red.

Associated with the lithium bearing pegmatites of the Winnipeg River district east of Point du Bois (Sec. 16, Tp. 16, Rge. 16E.) are deposits of the green chromium-bearing mica fuchsite, for which use is now being found as a decorative stone in stucco work. It is of a deep, vivid green color, very uniform in shade, and resists weathering fairly well. At a time when bright color contrasts in stucco work for exterior house-finishing are in vogue, there is little doubt that fuchsite will play a not inconsiderable part in the building trade. It is crushed to sizes of

half inch dimensions, and is used with calcite crystals from the lake Superior silver properties at Port Arthur, or with black slag, with good color effect.

No gem stones of highest quality have been found in the province. There are, however, some interesting occurrences of stones which may prove to be of value for decorative purposes. One-third of a mile north of the east end of Birse lake, an occurrence of rose quartz in a pegmatite offers possibilities in the gem industry. The exposure is 100 by 20 feet, and has a color and transparency of good grade. There is a good demand for rose quartz in small, well selected lots. Further west, at the northeast end of Bernic lake, beryl crystals are found in the lithium-bearing pegmatites. In places the beryl is clear and transparent, and may have gem value. The garnets in the mica schist at the east end of Anderson lake (west of Herb lake) associated with staurolite and pinkish cyanite, are of good museum grade as large, well formed crystals, but not of good color as ornamental stones. Small garnets in gneiss at Oxford lake show very good color. A variety of amber (chemahawinite) from the west end of Cedar lake has been gathered from time to time as a semi-ornamental stone. It is not a true amber, and is only fairly translucent. It is, moreover, obtained in sizes averaging less than one half inch in diameter. It is found mixed with decaying vegetable material in the mud in beaches and former beaches south of the Cedar lake (Chemahawin) post of the Hudson's Bay Company. The material has been of interest in recent years to the paint and varnish manufacturers, but to date has not been developed. It is probably the fossil resin of conifers of Cretaceous times.

SEE ALSO—

Report on the Building and Ornamental Stones of Canada, (Vol. IV, 1916, Mines Branch, Dept. of Mines), by W. A. Parks.

SANDS

There are three sandstone horizons in the province from which sand is available: 1st, the Winnipeg sandstone, on Black island, Punk island, Grindstone point and Elk island on lake Winnipeg, and at the north end of Runninghouse lake; 2nd, the Dakota sandstone, on Swan river, Steeprock river, Red Deer river and other points in northwestern Manitoba; 3rd, the Foxhill sandstone, near Boissevain in southwestern Manitoba. There are as well the widely distributed sands of post-glacial age, found in ridges and hummocks at the surface, as eskers, outwash deposits and beaches, from which, at the present time, practically all the sand is obtained which is used throughout the province.

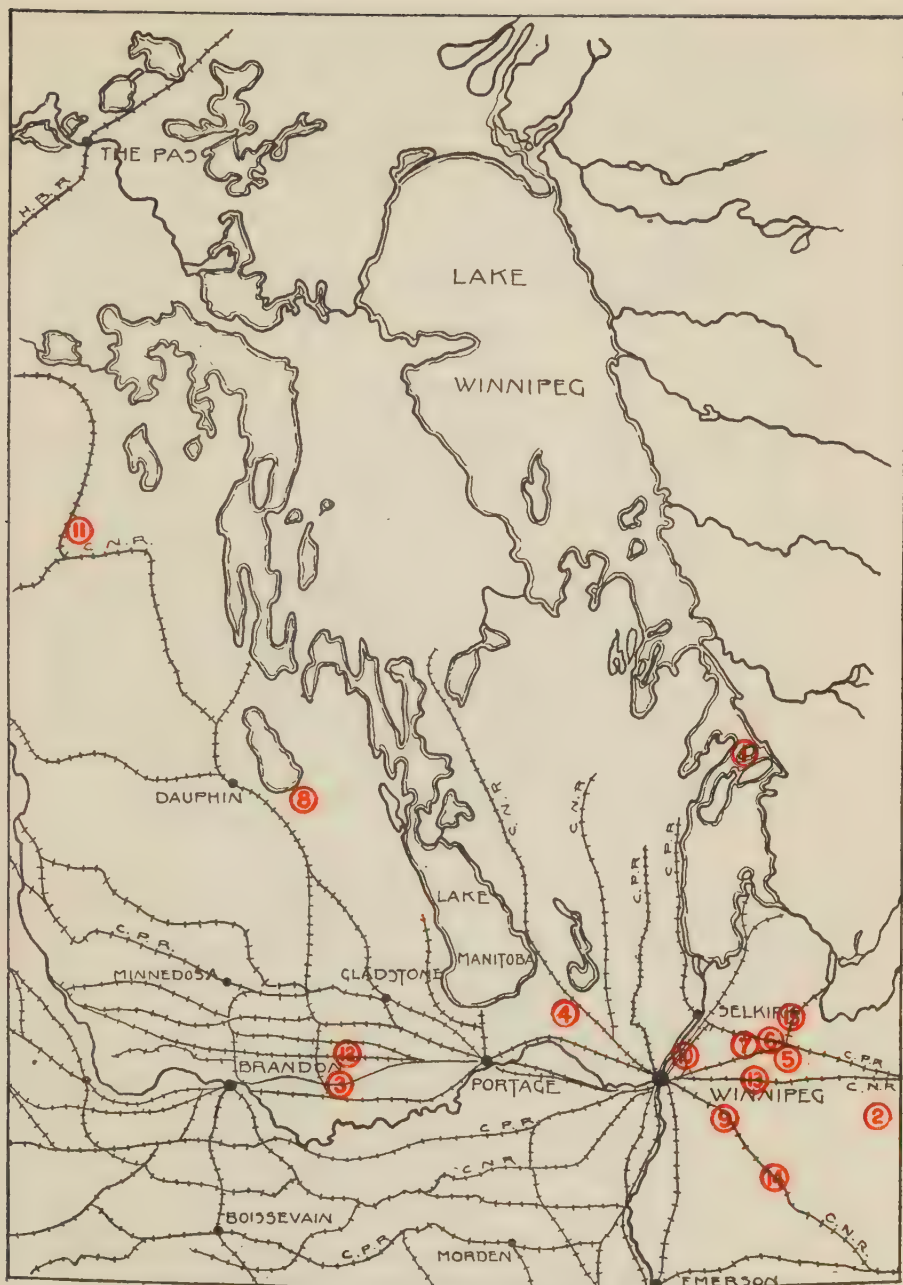


Fig. 8—Sand and Gravel Beds

1. Black Island
2. Mile 80—G.W.W.D. Ry.
3. Melbourne
4. Woodlands
5. Molson

6. St. Ouens
7. Beausejour
8. St. Rose du Lac
9. St. Anne
10. Bird's Hill

11. Swan River
12. Firdale
13. Vivian
14. Marchand
15. Smith Siding

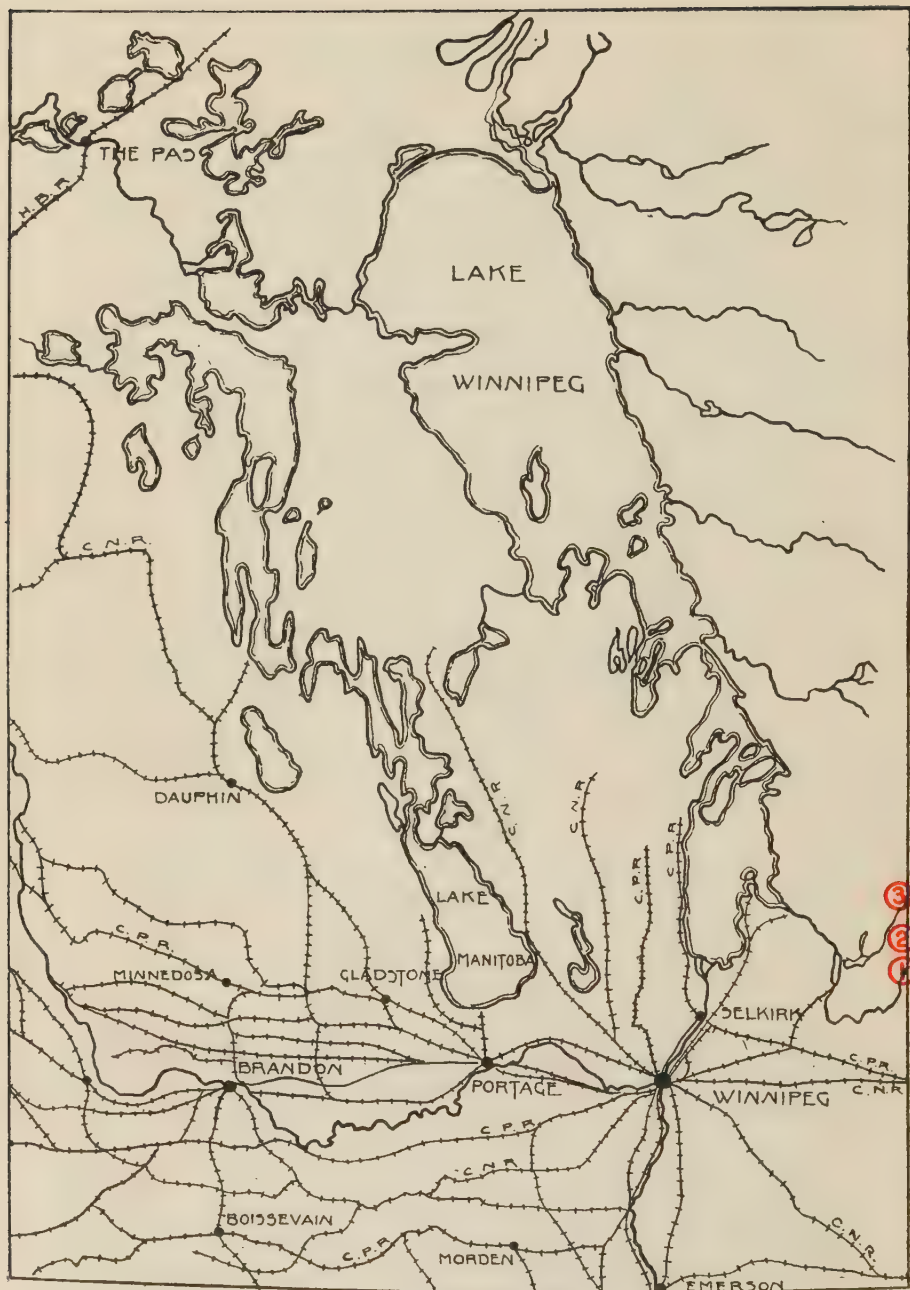


Fig. 9—Lithium Properties—

1. Silver Leaf Mining Syndicate
2. Bernic lake property (K. E. Miller)
3. Cat lake property

The demand for unconsolidated sands, as such, is confined to the requirements for sand-lime brick, for mortar, cement and concrete work, for moulding and core sands, for admixture in clay brick and as a parting sand in brick manufacture, as a filler in stucco work, for glass manufacture and for general flooring purposes. For all these purposes sand is now being used in the province, except for glass manufacture and as a stucco filler. For structural uses, for which the demands are somewhat elastic, a good deal of sand is got by screening from coarser gravel deposits. There are certain very definite requirements in sands, however, particularly for moulding practice and in glass manufacture, for which special sands must be supplied.

Moulding Sand—

For moulding sand, which is used in foundry work to provide a semi-porous envelope to the wooden pattern of the shape of the desired casting, the pattern then being removed and the molten metal poured into the cavity, the requirements depend on the type of the casting. For high temperature work, such as steel castings, sand of relatively coarse grain with limited bonding material is most satisfactory. For iron castings, intermediate types of sand, or mixtures of both types, are used. It is necessary in each particular case to find the correct combination of sufficient binding power, and with sufficient porosity to make possible the easy escape of liquids, vapors and gases; it is necessary also that no fusing of the binding material should take place, otherwise the porous spaces become choked and the sand rendered impermeable. For hollow castings, such as iron pipes, a core must be inserted in the mould. Core sands are built up, like other moulding sands, of a size to suit the requirements of the particular type of casting.

In Manitoba the practice has been to use a high grade silica sand from Ottawa, Illinois, for high temperature steel work, and to add, where necessary, an artificial bond such as molasses, to increase the binding power of the sand. For lining the bottom of furnaces, for which a good deal of high silica sand is used, no bond is needed. For this purpose, Black island sand tends to replace the Illinois sand. Black island sand is also coming into use as a core sand, in which porosity is a factor of special importance. The Black island sand (lake Winnipeg) and the Ottawa sand (Illinois) are remarkably similar in roundness of grain and chemical characteristics, the Illinois sand being, on the whole, of somewhat coarser grade. With proper treatment, the Black island sand will replace the Illinois sand for practically all purposes for which the latter is used. This will be discussed more fully in connection with glass sands.

For heavy iron castings, the moulding sand most in demand is the Gerrick (Minnesota) sand, a red sand with a very heavy

clay bond, carrying considerable iron. To date no local sand has been found with similar heavy binding qualities. Black island sand, with a strong artificial bond, might possibly meet the requirements for this work. For lighter work it has become the practice to mix Gerrick sand with local moulding sands which are finer in grain and which do not have so strong a bond; and to use local sands altogether for small castings and for brass-work. The local moulding sands which are being introduced into this class of foundry practice are; a surface (upper 3½ feet) sand at mile 80 G.W.W.D. line; a surface sand (upper 9 feet) at Melbourne Siding (C.P.R.), while a sand with no natural bond, from Marchand (C.N.R.) is being used, bonded with core oil, at one of the foundries as a core sand. These are all angular sands, with more or less clay coating around the grain, and with considerable dark heavy mineral. An unusually fine sand is found at Riley's pit (Molson, C.P.R.) 8 to 12 feet from the surface, underneath the gravel beds, which has little bond, but might be used for hand-cleaning preparations.

To summarise, it is probable that Black island sand, lake Winnipeg, when properly selected and washed, may replace the Ottawa (Illinois) sand for all high silica—high temperature foundry work. No sand has yet been discovered in the province with the qualities of the heavily bonded Gerrick (Minnesota) sand for the heavier iron castings; but for lighter work local moulding sands (G.W.W.D. and Melbourne) should in time supply the foundry demands. The total demand for foundry sand is as yet limited—between 75 and 100 cars for Winnipeg and district, including Selkirk. A small amount of special quality sand is also used in the brick industry as a parting sand. There is required for this purpose a sand sufficiently infusible to keep the bricks apart in the kiln, and sufficiently free from impurities to prevent discoloration. A bond is not needed in this kind of sand. It is at present obtained for the brick industry of the province at Molson, St. Ouens, G.W.W.D. pit at mile 80 and at St. Rose du Lac. The main demands for sand are in sand-lime bricks, the sand being obtained from Smith's Siding (C.P.R.), for the Bird's Hill Sandstone Brick Co., and from Marchand (C.N.R.), for the Winnipeg Brick Co.

For concrete, for mortar, and for general purposes, the main supply comes from Woodlands (C.N.R.); Braid & McCurdy's pit, Bird's Hill (C.N.R.); Great West Sand & Gravel Co.'s pit, Bird's Hill; from Marchand and south of St. Anne's (C.N.R.) and from Smith's Siding and Riley's pit at Molson (C.P.R.). Some of these pits supply mainly gravel. The sand for building requirements is coarser than for moulding purposes, free from clay and angular, but not necessarily high in silica. The output in sand and gravel from Woodlands and from the Great West

pit at Bird's Hill is in each case over 45,000 cubic yards per season.

Glass Sand—

The possibilities of a glass industry in the province are being carefully explored. For the manufacture of glass, high silica sands low in iron are needed, preferably of medium coarseness, of uniform grade and angular. No local sand fulfils all these requirements, but the sand on Black island, lake Winnipeg, is of a high grade of purity, with not too much iron for most types of glass. By washing, the sand can be graded up to high purity. It is a rounded sand of the following size in comparison with the Illinois (Ottawa) sand:

	Black island sand	Ottawa sand
	Percent	Percent
Through 20 mesh.....	97.2	98.8
Through 40 mesh.....	84.3	82.6
Through 60 mesh.....	57.7	56.2
Through 80 mesh.....	27.8	17.2
Through 100 mesh.....	14.6	9.0
Through 150 mesh.....	4.6	4.1

The following average analyses are given for comparison:

	Black island sand (Partial analysis)	Ottawa sand (Illinois)
	Percent	Percent
SiO ₂	97.70	99.48
Fe ₂ O ₃	.31	.02
Al ₂ O ₃	1.13	.15
CaO.....	.10	.11
MgO.....	.....	.05
Loss on Ignition.....	.....	.13

The Ottawa sand has been twice washed; the Black island sand is unwashed. By washing, the greater part of the alumina can be removed, and at least some of the iron. The similarity in the rounding of the grains of these two sands is so striking, and so different from the other sands of this area that the likelihood is that the two sands belong to the same (St. Peter's Sandstone) horizon. The Ottawa sand is already in use as a high grade glass sand. The other sands in the province which are of glass sand grade are the Dakota sandstone, and the Beausejour sand. The Dakota sandstone, which is exposed on Swan river, eight miles downstream from the town of Swan River, grades over 96% silica, is of relatively uniform size, and of angular grain. In its uniformity of size and its angularity, it has some advantages over the Black island sand, but in location, cost of quarrying, washing and transportation, the Black island sand is much better placed.

The Beausejour sand, a surface esker deposit, was used until 1913 for the bottle glass industry. The plant was bought out by the Dominion Glass Company, and sand was shipped from Beausejour to Radcliff, but not in recent years. This is not a high silica sand, containing as it does considerable mineral in addition to quartz. It is uniform in grade, fine-grained and angular and proved to be a satisfactory sand for bottle glass purposes during the time of operation. The glass industry requires, as well, salt cake, soda ash and limestone. The limestone is locally available and salt cake might be supplied from Saskatchewan, where glauber salt is now mined. With regard to raw materials, Winnipeg is favorably situated for glass manufacturing. It has been estimated that if a market of 80,000 gross of bottles can be assured annually, an industry could be established on a financially safe basis.

Physical Characteristics of the Sands—

The Winnipeg sandstone sands of Black island (Ordovician) are much more rounded and frosted than any other sands of later date. Neither the Dakota sands nor the Pleistocene sands have been much eroded. The Pleistocene sandgrains in particular, appear to have been fractured, probably by ice movement, and to have suffered no erosion since fracturing. The most complete grading on the other hand is to be found in some of the Pleistocene sands—particularly from the Assiniboine delta deposits (Firdale and Melbourne). These have doubtless been sorted by the action of the wind, and while of fine-grain, are fairly uniformly of the one grain. The Ordovician and Dakota sands are poorly graded. In heavy minerals the Pleistocene sands contain a richer and more varied assortment than the Winnipeg sandstone or the Dakota sandstone. The Winnipeg sandstone contains a remarkably limited assortment of heavy minerals, among which zircon predominates.

Field Relationships—

The Winnipeg sandstone and the Dakota sandstone are even bedded, the Pleistocene sands irregularly disposed. Diagonal bedding occurs rarely in the Winnipeg sandstone, and has not been observed in the Dakota sandstone. The Winnipeg sandstone in its exposures on Lake Winnipeg contains shale beds and markings which seem to be fucoïdal traces. In places it is iron-stained and concretionary; elsewhere a pure white sand. On the south side of Black island, which is, in the main, a Winnipeg sandstone island, a section of 33 feet of sandstone is exposed. The best exposure of the Dakota sandstone is on the north bank of Swan river (S.E. $\frac{1}{4}$ Sec. 8, Tp. 37, Rge. 26W.), where thin (one inch) lignite bands alternate with sand (four inch) beds in a 31 foot section. Several other exposures occur both up and

down the river. In an outcrop on the north bank of the Steep-rock river, one-and-a-half miles above the railway bridge, a greenish glauconitic sand of Dakota sandstone age is exposed. The Boissevain sandstone outcrops on the north flank of Turtle mountain; the sandstone shows at several places south of Boissevain. At Powne's farm, one mile south of town, the sandstone is exposed to a depth of 5 feet, showing cross bedding, and a weathering effect of the harder and softer bands. When this stone was being quarried at several shallow quarries south of Boissevain as a building stone for use in town from 1887 to 1894, it was found that the dip was sharply to the east, and heavy overburden was encountered. For that reason operations were confined to very shallow pits.

Of the Pleistocene deposits the eskers at Bird's Hill, Moose-nose, Beausejour, Vivian and Woodlands are made up of sharply contrasted beds of sand and gravel, characteristically cross bedded, and of operating depths up to 90 feet at one stage of operations at Bird's Hill. The deposit at Smith's Siding and Molson are outwash deposits associated with morainic ridges and contain boulder tills as well as reassorted gravel and sand. At St. Anne and Marchand the esker deposit has been remodified by outwash, and probably by beach action. Many of the lake Agassiz beaches are operated for gravel and sand, west of lake Winnipeg and at the base of the Pembina hills west of Roseisle. They are characteristically parallel bedded and of fairly uniform grade. At Sidney, Firdale and Melbourne the sand has been wind-assorted, is flat-bedded in parallel layers, and is normally of fine grades.

SEE ALSO—

The Glacial Lake Agassiz (Monograph XXV, United States Geological Survey, 1895), by W. Upham.

Bird's Hill, an Esker near Winnipeg, Manitoba (Bull. of the Geol. Soc. of America, Vol. 21, pages 407-432, pl. 31, pub. July 20th, 1910), by W. Upham.

SAND-LIME BRICK

Sand-lime (sandstone) brick is manufactured from sand and lime in the proportions of approximately 9 to 1, pressed into brick form at a pressure of 120 tons, and steamed for 8 hours at 125 lbs. steam pressure. Ochres are used to give a variety of color, the natural color being white. The lime is preferably a non-magnesia lime. The sand is not necessarily of high grade of purity, but should be angular and of fairly uniform grade. Sand-lime brick is used for interior partitions and outside walls. It hardens on exposure and weathers well except where it is in per-

manent contact with moisture or with smoke. In the lower tiers of a building in contact with ground moisture, or on chimneys, sand-lime brick will disintegrate and should not be used, otherwise this variety of brick has a wide and increasing market.

Two companies produce sand-lime brick in Manitoba at the present time. They are The Bird's Hill Sandstone Brick Co. (D. D. Woods & Sons), and The Winnipeg Brick and Fuel Co. Their combined production for 1926 was approximately 5,000,000 bricks which was considerably more than double the output of the previous year. The combined capacity is over 20,000,000 bricks per year. The Bird's Hill Sandstone Brick Company use sand from the Company's own sand pit at Smith's Siding, and lime from Spearhill. The Winnipeg Brick and Fuel Company obtain sand from the Marchand pit, and lime from Spearhill.

From 1908 until 1913 a sand-lime brick plant was operated at Beausejour, in which sand from the Beausejour sand ridge was used. When the Dominion Glass Company took over the bottleglass plant at Beausejour in 1913, the sand-lime brick plant was closed, and has not operated since that time. The hotel at Beausejour was built of this brick. A sand-lime brick was also manufactured for some time at Brandon, using local sand.

STUCCO MATERIAL

Recent years have witnessed a great increase in the use of stucco as an exterior finish on buildings. Stucco may be prepared either with Portland cement or with magnesia (Sorel) cement.

Portland cement stucco-work consists of a thin layer of concrete applied to a wall, the essential raw materials being cement, and gravel or crushed stone, all of which are available in large quantities in Manitoba.

"Magnesite" stucco is somewhat more complex. From 10 to 15 percent MgO is mixed with 85 to 90 percent of filler, the mixture being wet with a magnesium chloride solution of about 22° Baumé. Approximately 300 lbs. of magnesium chloride are necessary for one ton of stucco. Sand, powdered limestone, or calcite is commonly used as a filler. Each grain becomes coated over with a thin film of the oxychloride of magnesium formed by the magnesia and magnesium chloride. From 4 to 16 hours are required for the initial set. After the stucco has been applied to the walls a colored dash is generally thrown on. Granite, shells, calcite, furnace slag, felspar, glass and fuchsite are some of the dashes in favor at present.

Two firms in Winnipeg manufacture "magnesite" stucco as well as other magnesia cement products such as flooring tile. To date, however, but little of the raw material has been of

Manitoba origin. The magnesite is imported from California, where it is produced by the calcining of a magnesite containing more than 95 percent $MgCO_3$. No rock approaching this composition is known in Manitoba. Two processes have been developed in Germany for the extraction of magnesite from the lime-magnesia obtained by the calcining of magnesian limestones such as occur so plentifully in the province, but the efficiency of these methods in producing magnesite at low cost has yet to be proven. Magnesium chloride solution, too, must be imported from the United States.

It is to be regretted that so little of the filler has come from local points, only small quantities of the Black island sand having been employed. Too little variation in size of grain has precluded more extensive use. No limestone of sufficient whiteness appears to be available for this purpose. Calcite is being supplied from one of the old silver mines of the Port Arthur district.

Small amounts of granite, felspar, and fuchsite (a chromium-bearing mica of greenish tinge), from the Silver Leaf lithium property near Point du Bois, have been used for dash. To date approximately eight carloads of fuchsite have been mined for the stucco industry. Further development along this line seems likely. Furnace slag from local mills is also in demand for the same purpose.

II.—Fuels

COAL

The coal beds of Manitoba are confined, as far as present knowledge goes, to the Tertiary formations of Turtle mountain, and to the Dakota sandstone, where thin lignite seams are found in the sandstone. The Turtle mountain beds have been found in water wells, principally on the western and northern slopes of Turtle mountain, in southwestern Manitoba. The Dakota sandstone seams are exposed on Swan river, Steeprock river, and other erosion valleys on the east side of the Duck and Porcupine mountains. It is not improbable that some beds of coal may underlie the heavy drift covering at the top of the Riding, Duck and Porcupine mountains; but no drilling has yet been carried on near the top of these hills.

Coal has not played any part as an economic asset in the province. It would not be possible to work the thin beds in the Dakota sandstone; and the coal measures of the Turtle mountains are of the same nature as, but considerably smaller than, the deposits now being operated in the Estevan fields of southwestern Saskatchewan, and would be difficult to open up, in view of the competition of the larger field. Some attempts were made at one time to develop mines in this area, to which reference will be

made in a later paragraph, but no large quantity of coal has been produced. For the past 20 years there has been no coal mining in the Turtle mountain area.

The Turtle mountain series is of Tertiary (Eocene) age, resting on sandstones of presumably Foxhill age, exposed immediately south and southwest of Boissevain. The mountain reaches an elevation of somewhat over 2,450 feet above sea level, the elevation at Boissevain, which is practically on the plain, being 1681. The coal measures are found from elevations of 1,734 to 1,898 feet above sea level, that is, within the 200 feet of strata overlying the Foxhill sandstone. No deep drilling has been done on the higher elevations of the mountain, but a coal seam was found at 2,173 feet in a water well. Dowling, who mapped the coal seams on the flanks of the mountain in 1902, using in the main the evidence from waterwells, found that the seams are as a rule less than 3 feet thick, and that not more than three seams occur in any one well section. The sections at the Vaden mine and McArthur mine, the only properties from which coal has been taken, are typical of the well-drill records on the mountain. At the Vaden mine (Sec. 12, Tp. 1, Rge. 24W.) "the coal seam was struck at 40 feet, 4 feet 6 inches thick; then 12 feet of sandy shale and bands of iron ore; coal 1 foot 6 inches; then bored 35 feet through sandy shale; total 78 feet 6 inches." At a lower level, in the ravine, three seams $5\frac{1}{2}$, $3\frac{1}{2}$ and $1\frac{1}{2}$ feet in thickness were found in a well-section. Some coal was hauled out from the Vaden pit, and sold in Deloraine before 1890, when Dr. Selwyn reported on the pit. The elevation of the mouth of the pit was given by Dowling as 1,794 feet. The McArthur mine is on Sec. 11, Tp. 2, Rge. 23W., at an elevation, according to Dowling, of 1,825 feet. According to local information from Chas. Weaver, who worked on this property in 1896-97, two seams, respectively 2 feet and $1\frac{1}{2}$ feet thick, separated by 2 feet of fire-clay, were worked at a depth of 40 feet. Dr. Selwyn's record gives the seams as $2\frac{1}{2}$ feet and $2\frac{1}{2}$ feet, and at less than 23 feet in depth. Mr. Weaver states that the seams occasionally come together, and that a thickness of 5 feet has been found, but the thicker seam is considerably more broken. The mine was very wet, and some difficulty was encountered with the roof. Subsequently, in 1908, the mine was reopened by two Welshmen who were not able to carry on.

It will be gathered from a resume of the operations on the only pits which have produced coal, that the chances of successful operations on any large scale are small. Dowling estimated a total of 160,000,000 tons of coal on Turtle Mountain, all in the form of thin seams. It should be possible to get out coal for the use of the farmers of the district, as some of the seams can be reached without much excavation. With a small measure of local organization, and the employing of some competent coal miners, it would seem likely that the local fuel market can be

supplied more economically than from outside sources. Such operations would be justified, however, purely on the basis of the local market requirements. Exportation to outside points could not be carried on economically. There has been some recent interest in the matter of production owing to the finding in a drill hole of a 3½ foot seam of coal, 8 feet below the surface at the bottom of a ravine 115 feet deep on Powne's farm, (Sec. 25, Tp. 1, Rge. 24W.). The analysis of the coal (Milton Hersey Co.) gave the following:

	Percent
Moisture.....	11.16
Soluble Combustible matter.....	40.45
Fixed Carbon.....	41.85
Ash.....	6.55
Sulphur.....	1.06
B.T.U.....	10240

The analysis compares well with that of the Souris coal of southwestern Saskatchewan. It seems likely, however, that some of the moisture may have been lost in transit. Arrangements were on foot to operate this seam, but to date they have not materialised.

The coal beds in the Dakota sandstone are in the nature of pieces of lignite showing clearly the wood-structure, forming together somewhat irregular seams of beds. They have apparently been deposited in embayments in shallow encroaching seas, and may represent in some exposures the yearly supply of driftwood material covered by the sand of the sea. That seems strikingly the case in an exposure on Swan river (S.E.¼ Sec. 8, Tp. 37, Rge. 26W.), where thin 1 and 2 inch bands of lignite are separated by, on an average, 4 inches of sand. Sixty such bands can be counted in the section, which is underlain by a clay which contains considerable disseminated lignite material. There seems little doubt that this represents deposition of a seasonal type. The exposures of Dakota sandstone on Steeprock river on the eastern slope of the Porcupine hills, and at the rapids on the Carrot river, in Saskatchewan, west of the Pasquia hills, also show lignite bands, in the latter case of some thickness. The beds do not admit of working, as they are of very variable size, and have a roof of loose sandstone which would prove treacherous on excavation.

It is probably mainly from the Dakota sandstone that the coal which is frequently found in the drift throughout the province, has come. Such occurrences are reported from time to time. Usually the coal is found as single pieces of lignite of a woody structure, such as is characteristic of the Dakota sandstone seams. Though the exposures of this horizon are now few, the ice probably scraped the outcrop bare at many places along the

Manitoba escarpment, and carried forward the lignite bands, to be eventually distributed in the glacial drift.

SEE ALSO—

The Coal Fields of Manitoba, Saskatchewan, Alberta and Eastern British Columbia, (G.S.C. Memoir 53, No. 1363, 1914, 142 pages), by D. B. Dowling.

Peat, Lignite and Coal, (Mines Branch, Dept. of Mines, Ottawa, 1924), by B. F. Haanel.

OIL AND GAS

Geological Horizons—

There has been considerable prospecting for oil and gas in Manitoba during the past 20 years, more particularly in the western areas of the province. The main incentive to search for oil has been the evidences of the presence of oil at the surface in the shales which occur in the Benton and in the Niobrara horizons of the Cretaceous formation. The outcrops are most numerous, and most easily available, on the eastern flank of the hills which form the Manitoba escarpment, extending from the Pasquia hills south through the Porcupine, Duck and Riding mountains to the Pembina hills in the south. In the Niobrara shales, particularly, immediately above the limestone band which outcrops, for example, on the Assiniboine river, northwest of Treherne (N.E. $\frac{1}{4}$, Sec. 36, Tp. 8, Rge. 11W.), the oil content in the shale is highest (8 to 10 gallons per ton). In the exposures of this horizon, the evidences of oil are numerous, wherever the shale is exposed and weathered; and in those indications, as a rule, drilling has been begun. Such drilling has been carried on at Neepawa, Manitou, Treherne, Mafeking, and at Old Man river on the west side of Pasquia hills. Some evidence of oil in the shales also occurs in the Pierre shale overlying the Niobrara shale, as at Rapid City; but to a lesser degree than in the oil shales in the Niobrara horizon.

The other geological series in which considerable prospecting has been done is the limestone series of the Palaeozoic formations—the Ordovician, Silurian and Devonian systems in the great lakes area of Manitoba. In this there has been drilling at Winnipegosis, Rabbit Point, Lilyfield; and there has been very considerable deep drilling for water as well. The total thickness above the granite of the limestone with the basal sandstone is at Winnipegosis (N.W. $\frac{1}{4}$, Sec. 20, Tp. 30, Rge. 17), over 1,507 feet, and at Lilyfield approximately 714 feet. The limestone series is on the whole fairly flat lying, with a dip of 2 to 3 feet per mile to the southwest, and occasional dome structures, particularly in the Devonian limestones. In a typical dome or anticlinal fold southeast of Winnipegosis, drilling was carried on to

the granite through the limestone series, but without obtaining any evidence of oil. Nor have any of the other holes in the Palaeozoic limestones shown indications of oil that would justify any considerable expenditures in investigating the Palaeozoic limestones. No structures more favorable than the Devonian domes have yet been found, and the limestones which, in Ontario and neighboring states to the south are oil-bearing do not, from exploration to date, give much encouragement here.

In the Cretaceous shales the conditions are to this extent more favorable that there are oil shale horizons. This is not in itself necessarily favorable for oil, and would only be favorable if major folds made possible the expressing of the oil from the shale into a carrying horizon such as the underlying Dakota sandstone, where it would be capped and prevented from escaping by the impervious overlying shales. Where the Dakota sandstone is exposed, as on the Swan river or on the Carrot river, there is no indication of bituminous material or oil residue, but the Dakota sandstone is rarely exposed. There is the danger that if oil had accumulated in this formation, it may have escaped through insufficient capping on the eastern flank of the Manitoba escarpment. More definite traces of the former presence of oil would probably have been left in the sandstone than have yet been found. The structures which have been determined are minor flexures, probably insufficient to be of importance in the accumulation of oil. No major flexure has been noted; and the suggestion that the line of hills of the Manitoba escarpment is in itself the result of a fold has no basis in geological fact, and should not be entertained. Only where there can be definitely worked out a structural fold of considerable proportions, at a place where the oil shales immediately overlying the limestone horizon of the Niobrara formation are well capped, should drilling be carried on. The indications of oil in exposed Niobrara oil shale are no justification in themselves for oil exploration.

Particular Localities—

At Rapid City, and in the district southwards to Levine and northwards to Minnedosa, there has been some prospecting for oil. The exposed rock in this area, in the cuttings of the C.N.R., eastwards to Tremaine, are in Pierre shale, which shows several local flexures, but has a general northeasterly dip so far as the limited exposures would indicate. The exact position in the Pierre shales could not be ascertained. A limestone formation north of Levine which it had been suggested might possibly be the limestone of the Niobrara, thus indicating an important elevation of the Niobrara and a major flexure, was found on examination to be a marl deposit from surface springs, and of recent age, and consequently of no significance in interpreting structure. There has been practically no drilling for oil, though

some little work was done in the valley of the Minnedosa river, southwest of Minnedosa. The deepest water-well was 400 feet, but no direct information is available as to the nature of the shale obtained. With the normal regional dip to the southwest, the limestone formation of the Niobrara immediately overlying the oil shales would be 669 feet below the valley of the Minnedosa river at Rapid City, and the top of the Dakota sandstone would be 1,013 feet below the surface at the same place. Six miles northwest of Rapid City the depths would be 250 feet more than the figures above quoted, owing to the higher elevations. These are maximum figures, estimated on the assumption of a gradual southwestward dip. At Rapid City the dip is locally in the reverse direction, and the depths would probably be somewhat smaller than the figures above given. There is a possibility that this reversal of dip may indicate the eastern limb of a fold; but exposures of shale have not been found to the west such as might assist in unravelling the structure. The railway cuts at Rivers are all in glacial material, and do not reach the shales. Further examination carried on up the Minnedosa river beyond Newdale will assist in interpreting the structure of this area.

In the Mafeking district on the east flank of the Porcupine mountain there has been very considerable prospecting for oil during the last five years by three organizations, six holes having been sunk (one by core drill) to a depth varying from 1,200 to 1,800 feet. Activity was confined to the area between Steep Rock river (to the north), Bell river (to the south), the foothills or first terrace of the mountain to the west, and a line approximately one mile east of the railway line to the east. The elevation of the railway line in this block is from 1,061 to 1,068 (Mafeking), and the first terrace of the mountain rises some 400 feet above that elevation. Sections on Bell river (3 miles above railway crossing) and on Steep Rock river (one and a half miles above railway crossing), indicate that the foothill terrace is very dark Benton shale incrustated with sulphur on surface exposures, and that the sandy plain below the terrace is in Dakota sandstone which contains some glauconitic sand. The Steep Rock river exposure shows the Dakota sandstone, and the Bell river exposure the Benton shale. Two of the drill holes began in Benton shale and the other three (including the core drill), in Dakota sandstone. One hole was drilled where the Bell river cuts through the foothill scarp—about 300 feet in elevation above the railway crossing—to a depth of approximately 1,400 feet; another on the foothill terrace three miles west southwest of Mafeking, to a depth of approximately 1,800 feet. These were drilled in Benton and underlying formations. Two test holes were put down on Steep Rock river, one a mile below and the other one-and-a-quarter miles above the railway crossing, both to a depth of approximately 1,200 feet; while the core drill hole was

sunk one mile west of Mafeking, at an elevation of approximately 1,140 feet in Dakota sandstone and underlying formations. Granite was reached at 1,562 feet, and the drilling stopped at 1,627 feet depth. In all the drilling in this district the aim seemed to be to prospect for oil in the Palaeozoic limestones underneath the Dakota sandstone, even although they are capped in this area, and their structures cannot be prospected at the surface. As already indicated, it would seem more profitable here as elsewhere on the escarpment to base exploration work on the possibility of the oil in the shales overlying the Benton (particularly the Niobrara) being expressed by folding and held in the Dakota sandstones or other possible Cretaceous horizon. For this it would be necessary to drill much further back in the Porcupine hills than the first scarp (the foothills), which is made up of the lower Benton shales. The core drill section of the whole of the Palaeozoic series is of great value from many points of view, and the exploration work, while unsuccessful in finding oil, has provided a record which will be of assistance in future exploration.

At Ochre river the McIntosh well is on the N.W. corner of Sec. 30, Tp. 22, Rge. 17W. The Riddell (Holmes) well is about half a mile further east. Ochre River station is 10 miles north of the wells. The elevation of the McIntosh well is 1,247 feet, that of the Riddell well 1,200 feet. The occurrence of a heavy limestone band (5 feet) in the cut bank of carbonaceous shale immediately below the site of the Riddell well would indicate that the well is in Niobrara shales immediately above the top of the Benton series. The Riddell well is sunk on an 8 inch band of bluish limestone, separated from an overlying 5 foot bed of brownish limestone by 20 feet of carbonaceous shale. The core drill shows a remarkable thickness of gypsum. From a depth of 428 feet to 625 feet, gypsum is associated with the limestone; and again from 700 feet to 830 feet gypsum occurs again associated with the limestone. The gypsum does not appear to run in massive beds, but rather in thin bands, and as pockets in the limestone. The solid limestone begins at a depth of 390 feet from the surface, being overlaid by calcareous shale.

At Grandview some drilling was done during 1926 on the N.W. $\frac{1}{4}$ of Sec. 18, Tp. 16, Rge. 24W., seven miles northwest of Grandview. The elevation is approximately 1,557 feet, in open country with no exposures in the immediate vicinity. Two shallow holes were put down in the drift and underlying Pierre shales.

The drilling at Treherne will be discussed under the heading of Gas. A deep well was also sunk at Neepawa (altitude 1,208 feet). A strong flow of salt water was struck at a depth of 1,165 feet. Gypsum was reported at a depth of somewhat over 1,100 feet. The following is the log of the well drilled south of Manitou (S.E. $\frac{1}{4}$ Sec. 23, Tp. 2, Rge. 9), 1,270 feet above sea level:

Depth	Description of Strata	Formation
0 to 450 feet.....	Dark and light-grey soft shales with nodules of pyrites.	Pierre shales, Cretaceous.
About 425 to about 610 feet	Soft blue-grey lime shales with pyrite and shells of lime.	Niobrara, Cretaceous.
About 610 to 716 feet	Dark blue-green glauconitic shales, shells of lime, and with two beds of limestone at 675 ft. (natural gas, very strong flow) and 714 ft.	Benton, Cretaceous.
716 to 760 feet	Coarse white soft sand with a great deal of iron pyrites and fragments of coal. This sand proved to be a regular quick-sand which ran in the well and at the bottom of it passed for a few feet into a calcareous conglomerate of arkose.	Dakota sand and lower Cretaceous.
760 to 790 feet	Vermilion and yellow clay shale or shaly limestone with pyrites.	Upper Devonian.
790 to 925 feet bottom of well.	Greyish greenish and light-grey soft lime unctuous shales often described by drillers as "soapstone."	Devonian.
925 feet.....	Strong showing of gas and film of blue oil.	

In the Palaeozoic limestones the most important investigations have been made southeast of Winnipegosis (N.W. $\frac{1}{4}$ Sec. 29, Tp. 30, Rge. 17W), near the lake, immediately south of Snake island. Some indications of oil in a well near Dauphin led to the investigation of a typical Devonian dome by the Provincial Government, and this particular dome was chosen. The Palaeozoic section was found to be much thicker (over 1,507 feet) than was expected; but no indication of oil was obtained. At Lilyfield, west of Stony Mountain, the granite was reached on core drilling at 714 feet, and was penetrated for several hundred feet. In this latter case the selection of drilling location was not made on the basis of any structural features, and the results do not justify further exploration in this area. A very interesting feature in this core drill section was the evidence that the granite underlying the Palaeozoic series is much weathered, and to a very considerable depth.

The results of the work to date on search for oil point to the need for care in any future explorations. Little of a reassuring nature has yet been found, and future work should be based on clear-cut evidence of oil seepage, or on carefully worked out struc-

tures of a favorable type. Much work will yet be done on the higher elevations of the Riding, Duck and Porcupine mountains; and the more northerly limestone areas will yet be explored. It has recently been suggested that the elevations of the pre-Cambrian surface buried beneath the Palaeozoic series might serve as gathering ground for oil. A striking elevation reaches the surface at the Narrows of lake St. Martin and northwestward. The presence of such buried elevations, if they occur, might best be indicated by torsion balance or magnetometric survey.

GAS

The presence of gas, which has been found mainly in the oil shale horizons, has been taken as an indication of oil in the Treherne district. The gas well on E. C. Haskell's farm (N.E. $\frac{1}{4}$ Sec. 28, Tp. 7, Rge. 10W.), was sunk at an elevation of 1265 feet to a depth of 250 feet. The gas was obtained at 150 feet, and has been used for 15 years for kitchen and dining-room lighting, and occasionally for a small gas heater for cooking. Drilling for oil has been carried on in 1926 more than half a mile away on the southeast corner of the same quarter section at an elevation of 1281 feet. It is understood that the drilling reached a depth of 250 feet when financial difficulties arose, and work has not been resumed. The cement beds of the Babcock horizon are exposed here at an elevation of 1244 feet (N.E. corner of Sec. 34), and the limestone horizon of the Niobrara at an elevation of 975 feet (N.E. $\frac{1}{4}$ Sec. 36, Tp. 8, Rge. 11W.) on the Assiniboine river, with the oil shales immediately overlying the limestone band. The depth from the top of the casing to the Dakota sandstone may be estimated at 650 feet maximum and might be 100 feet less. It would be inadvisable in any event to drill below the base of the Dakota sandstone into the limestones, as the Dakota sandstone would be the receptacle for any oil which might be connected in origin with the oil shales. No folding of significance for oil prospecting was noted in this area. Gas is being used as well south of Rathwell (S.W. $\frac{1}{4}$ Sec. 21, Tp. 7, Rge. 8W.) at the farm of Frank Bosc, where a well was sunk at an elevation of 1200 feet to a depth of 210 feet. Gas was got at 170 feet, and is used continuously for one light in the kitchen, and has been used for six years. The gas in both cases (south of Rathwell and southwest of Treherne) evidently comes from the 200 feet horizon of carbonaceous shale (G.S.C. Summary Report 1915, p. 132) overlying the hard limestone band of the Niobrara horizon.

At Robert Hall's farm (N.W. $\frac{1}{4}$ Sec. 14, Tp. 6, Rge. 22W.) gas was struck in 1926 at a depth of 190-210 feet in a search for water. The elevation of the top of the well is approximately 1480 feet. When the well was examined in November 1926, it was found to be capped by half inch pipe, and the gas pressure registered 48 pounds, which was reduced to 35 pounds on permitting the gas to escape for several minutes. A measurement taken after permitting the gas to escape for five hours gave a pressure of 45 pounds. A sample of the gas was handed to Dr. Shipley of the University for analysis, who reported as follows:—

	Percent.
Combustible, mostly methane, but a small percentage of a heavier hydrocarbon.....	75.4
CO ₂	0.0
O ₂	4.0
H ₂	0.0
Residual non-combustible.....	20.6

Practically 80% of the gas is of value for light or heat, the remainder being of no value. If the pressure can be maintained, the gas could be of value for cooking, and probably for heating purposes.

At Waskada four wells are in active use—those of F. Clement, G. R. McLean and W. S. Cameron in town, and that of T. Wright on Sec. 8, Tp. 2, Rge. 25W., one mile N.E. of town. The wells were dug about 15 years ago, and showed a pressure, several years ago, of 14 pounds. The depth varies from 190 to 240 feet, in Pierre shales. The elevation at Waskada is 1549 feet. The gas is used for lighting and cooking purposes, and has been found, though not used, in several of the wells which have been dug in the neighborhood of Waskada. The gas is almost odorless and dry. The pipelines, which in the Clement and McLean wells, run a considerable distance along the street, are unprotected and are not blocked by freezing. No attempt has been made in the Waskada district to use the gas for heating purposes. The greatest pressure is at F. Clement's well, where a cookstove and seven lights are in operation. South of Sourisford, at the farm of J. B. Elliott (S.W. $\frac{1}{2}$ Sec. 10, Tp. 2, Rge. 27W.), 12 miles south of Melita, a well was drilled for gas on the east bank of South Antler creek about 20 years ago. The depth of the well was 212 feet, and the gas was got some distance above that depth. The gas was led into the house 800 feet away, and has been used for cooking, and for a five-burner lamp, continuously since that time. The pressure was at one time measured at 19 pounds. Gas is seen to escape at several places on South Antler creek in this vicinity. At Melita gas was used for lighting purposes in the engine room of the grist mill (now dismantled) nearly 20 years ago. There has been some indication of gas

also in the Broomhill district, but it has not been put to use in this locality.

As far as the general situation is concerned, there are apparently several pockets in Niobrara and Pierre shale, which are of sufficient importance to make it worth while to pipe the gas into the houses for lighting and cooking purposes. The greatest pressure which has been registered is 45 pounds. The most extensive field is in the Pierre shale in the Waskada—Sourisford—Melita district, which is probably connected with the Bottineau gas field of North Dakota. It might be feasible to increase the volume by combining a number of wells, and use the gas for general distribution in Waskada or Melita. It would, however, be more advisable, for preliminary development, to extend greatly the use of individual wells. This source of light and fuel supply should be taken advantage of by the inhabitants of the district to a much greater extent than is at present the case. SEE ALSO—

Oil and Gas Prospects of the Northwest Provinces of Canada (Memoir No. 29, 1913, G.S.C.), by W. Malcolm.

Cretaceous Shales of Manitoba and Saskatchewan—Their Economic Value as a Possible Source of Crude Petroleum (Mines Branch, Dept. of Mines, Can. Mem. Series, Dec. 1921, No. 3), by S. C. Ellis.

OILSHALES

The demands which are being made in this continent on the available resources of oil in the form of reservoirs are so great that it will be necessary within 20 years—unless very large oil pools are discovered—to turn to the supplies available by distillation of oilshales. This means of obtaining oil has long been made use of in older countries. In Scotland, for example, oil bearing shales are mined at depth like coal and supply on distillation not only oil but ammonium sulphate for fertilizing purposes as well. Up to the present time it has not been found possible to distil oilshales in the North American continent in competition with the very large supply of oil available from wells. The bituminous shales are found in quantity—particularly in Utah, Colorado and Montana, where attempts have already been made to distil by retorts of the Scottish and other types. In these states the shales contain up to 35-40 gallons of oil per ton and are easily available in high exposures. There is not yet, however, a large market for the ammonium sulphate by-product in the Western United States, though this market will undoubtedly arise with the impoverishing of the nitrogenous content of the soil.

In Manitoba the Cretaceous shales of Niobrara and Pierreage are in part bituminous. The Benton shales are carbon-

aceous and show coatings of sulphur on exposed surfaces. The Niobrara shales are in part calcareous, containing a limestone bed filled with *Ostrea* and *Inoceramus* shells, as exposed on Assiniboine river northwest of Treherne (N.E. $\frac{1}{4}$ Sec. 36, Tp. 8, Rge. 11W.), and a cement bed from which natural cement has been manufactured at Babcock. Between these two horizons lie 200 feet of carbonaceous shales from which the highest values in oil have been obtained. The elevation of the limestone ledge which is the bottom of the shales on the Assiniboine river northwest of Treherne (N.E. $\frac{1}{4}$ Sec. 36, Tp. 8, Rge. 11W.) is 975 feet. The strike of the shales is N.N.W. and this elevation may be taken to represent approximately the bottom of the shales along a north-north-westerly line passing through this point.

Shales from some of the most accessible exposures of the Niobrara formations in the Manitoba escarpment have been sampled by Ells with the following results:—

Locality	Imperial gals. crude petroleum per ton*	Spr. gr. of crude petroleum at 60°F.	Imperial gals. water per ton
Birch river 31-39-26W.....	0		42.7
Favel river 30-35-25W.....	6.2	0.972	12.1
26-35-26W.....	6.8	0.984	7.0
26-35-26W.....	5.9	0.965	15.2
Sclater river 15-34-23W.....	4.8-7.5	0.966-0.968	9.2-18.7
Pine river 6-33-22W.....	3.3	0.969	4.5
Vermilion river 12-24-20W....	1.1-5.1	0.952	8.1-22.0
Ochre river 29-22-17W.....	4.0-5.3	0.955	14.6-15.2

These values are much too low for successful operation, though they might provide the source of oil reservoirs in suitable carrying formations, if widespread folding has anywhere taken place. Search has been made in several districts (see under Oil and Gas) for such reservoirs, to date without success. Pockets of gas, in some cases under considerable pressure, have been found apparently associated with the carbonaceous shale of the Niobrara formations south of Treherne and of Rathwell; while south of Souris and at Sourisford gas is found associated with the upper Pierre shales.

On the farm of W. Hunter, Sec. 30, Tp. 35, Rge. 25W, four miles south of Minitonas, carbonaceous oil shale has been burning for the past 10 years. This is at a cutbank of 25 feet of shale on the East Favel river, at an elevation of approximately 1220 feet. The only indication at the surface of the burning shale is the strong smell of SO_2 , and the fact that the shales are slightly

(*) Calculations based on ton of 2,000 pounds.

warm. One mile north and approximately 6400 feet west of this exposure the following section of Niobrara shale is exposed:

5 feet brownish soft limestone
 30 feet soft black carbonaceous shale
 4 inches bentonitic clay
 15 feet soft black carbonaceous shale

The burning shale is probably above the five-foot bed, which is by barometer 1213 feet in elevation.

SEE ALSO—

Pembina Mountains, Manitoba, (XVIII, pages 131-133, Summary Report, Geol. Survey of Canada, 1915), by A. MacLean.

Cretaceous Shales of Manitoba and Saskatchewan—Their Economic Value as a Possible Source of Crude Petroleum (Mines Branch, Dept. of Mines, Can. Mem. Series, Dec. 1921, No. 3), by S. C. Ells.

PEAT

Many parts of Manitoba, particularly some of the Pre-Cambrian areas, are very swampy as a result of glacial action blocking up the older drainage systems. These swamps and muskegs are gradually filling up with plant growth, some of which has already been partly transformed into peat. The following tables present the salient facts concerning the investigated peat bogs of Manitoba. (*)

For Table, see page 59.

Partial Analysis of Absolutely Dry Peat

Peat Bog	Volatile Matter	Fixed Carbon	Ash	Nitrogen	Calorific Value B.T.U.
	Percent	Percent	Percent	Percent	Per lb.
Lac du Bonnet.....	59.4	25.0	15.6	.....	.....
Transmission.....	56.8	24.2	19.0	.....	.....
Corduroy.....	56.1	34.8	9.1	.....	.....
Boggy Creek.....	65.0	26.7	8.3	.....	8730
Mud Lake.....	69.1	23.2	7.7	.....	8760
Litter.....	66.1	26.2	7.7	.....	9090

In addition to the above, some 236,000 acres of peat bogs in southern Manitoba have been surveyed in a preliminary fashion, the most important being the Whitemouth bog, it having an area

(*) Investigations of the Peat Bogs and Peat Industry of Canada, 1910-11 (Mines Branch, Can. Dept. of Mines), by A. Anrep.

PEAT BOGS	Approx. area	Less than 5 ft. deep	5 ft. to 10 ft. deep	10 ft. to 15 ft. deep	Over 15 ft. deep	Approx. contents	Estimated workable volume	Estimated possible production of Fuel with 25% moisture	Estimated possible production of Litter with 20% moisture	Legal Description
Lac du Bonnet....	Acres	Acres	Acres	Acres	Acres	Cu. Yds.	Cu. Yds.	Tons	Tons	Tp. 14, Rge. 10E.
	250	180	70			1,258,400	445,280	59,000		
Transmission.....	1375	1375				10,648,900	7,022,840	936,000		Tp. 15, Rge. 12E.
Corduroy	100					649,000	322,660	43,000		Tp. 15, Rge. 12E.
Boggy Creek	660						4,257,050	568,000		Tp. 15, Rge. 12-13E.
Mud Lake	140		140			2,011,700	1,564,630	209,000		Tp. 15, Rge. 14E.
Litter	110		28	40	42	2,116,500	1,389,740 } 361,390 }	48,000	104,000	Tp. 15, Rge. 14E.
Julius	3900	1000	1954	946		44,382,500	32,651,750		2,449,000	Tp. 11-12, Rge. 10E.
Rice Lake	Very small									Tp. 15, Rge. 13E.
Total	6535							1,863,000	2,553,000	

of 97,000 acres, and an average depth in the middle of 11 to 12 feet. Extensive peat beds also occur north of the Saskatchewan river on the northwest end of lake Winnipeg. Some of the bogs present possibilities from the standpoint of peat manufacture, but most of them are not suitable, being too shallow, too small, or not sufficiently humified. In 1907, a peat briquetting plant was erected near the railroad track, four miles southwest of Lac du Bonnet. Peat was obtained from a small bog traversed by the railway. Operations ceased in 1908 and the machinery was dismantled.

The Peat Committee appointed by the Ontario and Federal governments has done considerable work on this problem. After several years of experimenting, the committee has devised a practical excavating, pulping, and spreading machine and has operated it in the Alfred Bog, Prescott County, Ontario. The results were so encouraging that private interests have taken over the plant and it is expected that operations on a commercial basis will soon commence.

While Manitoba's fuel problem is not as acute as is Ontario's, yet the Alfred experiment is of more than passing interest in view of the considerable peat reserves in the province.

Briquetting of peat has been attempted but has not proven a commercial success. The manufacture of wall-board from peat and moss has been suggested and some work has been done in this direction.

III.—Miscellaneous Minerals

BENTONITE

Of late years interest has been displayed in a peculiar variety of clay known as "bentonite." In Canada it was first found at Camrose, Alberta, in 1911. Since then, several deposits have been located at various points in British Columbia and Alberta. The origin of bentonite has not been satisfactorily explained, but it is thought to be derived from volcanic ash.

No search has been carried on in Manitoba for this interesting mineral, but in 1914, A. MacLean (*) of the Canadian Geological Survey noted an occurrence in the Upper Niobrara formation of 50 feet of a clay very similar to bentonite. He recorded it as being exposed in the Pembina valley from the International boundary to the E. $\frac{1}{2}$ of Sec. 23, Tp. 2, Rge. 9W., in Dead Horse

(*) Pembina Mountain, Manitoba—A. MacLean, Summary Report of the Geological Survey, Department of Mines, 1914.

valley in Sec. 20, Tp. 2, Rge. 6W., and on the east side of the Pembina escarpment in Tp. 1, Rge. 5.

No further details were given so some of these occurrences were visited in 1927. Good exposures were difficult to find, but a certain amount of clay having bentonitic properties was noted. How this clay compares with the Alberta and Wyoming bentonites has not been determined. The most extensive occurrence observed, is on the S.E. corner of Sec. 13, Tp. 1, Rge. 7W., about one half mile east of the bridge spanning the Pembina river. Here at an elevation of approximately 90 feet above the river a cut bank of about 40 feet in height shows a considerable thickness of bentonitic clay. The exact thickness could not be determined as the stratification was obscured by material from the top beds which had been washed down. The shales were not exposed at this point; four feet of a loamy clay overlie the deposit.

Other occurrences farther up the river were visited. In all cases they consisted of beds having a maximum thickness of 1 foot, interstratified with both the grey and brown shales.

On the N.W. corner of Sec. 22, Tp. 1, Rge. 6W., is a poor exposure of bentonitic clay at the bottom of a ravine cut by a small tributary of Dead Horse creek. A thickness of approximately 14 feet is apparently indicated.

The clay from these occurrences undoubtedly has bentonitic properties, swelling very appreciably when immersed in water, having a soapy feel when wet, and being exceedingly fine-grained. It does not harden on exposure, however, like the Alberta bentonite. Probably a certain proportion of mud or clay is present. More prolonged search might disclose many more outcrops.

A 4 inch layer of bentonite occurs in the Upper Niobrara shales, four miles south of Minitonas. At Ninette a 2 inch bed was found, interstratified with the Pierre shale.

Paper manufacturers have been the chief users of bentonite, as it gives body and weight to their product. Other uses have been as an adulterant in cheap candy, and as a constituent of a well-known poulticing preparation. It also appears to be well fitted for many other purposes.

FELSPAR

In this province, pegmatite dykes are common features of the pre-Cambrian complex and are especially numerous in southeastern Manitoba. West of Point du Bois and east of Lamprey Falls they attain large dimensions. Frequently the felspar content is very high—in some cases probably 95 percent. In many of the dykes the quartz and felspar are not intimately intergrown and could be separated very easily.

Felspar is in demand by the ceramic industry, being used in the manufacture of high grade pottery, porcelain, enamelware, glazes, and insulators. The lower grade spar is used for stucco work, roofing, poultry grit, abrasive soaps and in the manufacture of opalescent glass.

No. 1 felspar must have at least 12 percent potash content, carry not more than 10 percent quartz, and not more than one half ounce of one percent iron. The grade must be strictly uniform so that fusion will take place at a constant temperature.

The average price paid for crude felspar in Canada during 1926 was \$8.50 per ton, f.o.b. cars at shipping points. Most of the output from Ontario and Quebec is exported to the United States in the unground state, chiefly to the potteries of Ohio and New Jersey, the domestic demand being very small.

SEE ALSO—

Geology and Mineral Deposits of Oiseau River Map-area, Manitoba, (Summary Report, 1924, Part B, G.S.C.), by J. F. Wright.

Canadian Felspar in 1922 by V. L. Eardley-Wilmot, (Summary Report on Mines Branch Investigations, 1922, Canadian Department of Mines.)

GARNET

The main use of garnets is in the manufacture of abrasive papers and cloths. These materials are necessary for the polishing of wood and leather work. Garnets for this purpose should have a hardness of from 7 to 7.5 in Moh's scale and the crushed grain must possess a sharp cutting edge. Although many occurrences in Canada are known, only a small production from Bancroft in Hastings Country and from Depot Harbor, in the Parry Sound district, both in Ontario, has been recorded of recent years. Garnets of good quality sell for approximately \$85 per ton f.o.b. mine in the United States. A duty of 10 percent is levied against the imported mineral.

Little attention has been paid to the occurrence of garnets in this province as there is no local demand for this mineral and prices quoted do not permit shipping for great distances. Nevertheless there is reason to believe that deposits do exist which may be of value in the future.

Alcock (*) describes an occurrence near Wekusko lake as follows: "Immediately east of the outlet of Anderson lake a ridge approximately 1,500 feet long and from 100 to 200 feet wide extends in a northeast direction The ridge of schist is

(*) The Reed—Wekusko Map-area, Northern Manitoba (Can. Dept. of Mines, Geological Survey Memoir 119, 1920, p. 22), by F. J. Alcock.

well exposed throughout The commonest variety is a biotite schist containing both staurolite and garnet. Towards the northeast end of the ridge a garnetiferous mica schist is developed in which garnet rhombic dodecahedrons varying in size up to $2\frac{1}{2}$ inches, comprise most of the rock."

Quoting Wright (*) "Besides the sediments previously described associated with the lavas along Winnipeg river there are other thinner and more local beds of clay-like material and red garnet These beds alternate with others estimated to be three-quarters garnet, in red crystals under one half inch in size, and set in a quartz matrix. One garnet bed about 6 feet in width and 250 feet long was noted on the south shore of Winnipeg river, Sec. 29, Tp. 16, Rge. 16." "The garnet-rich rock outcrops along Winnipeg river, in Secs. 21 and 28, Tp. 16, Rge. 16. The garnet is a deep red variety and occurs in well-developed crystals up to one half inch in diameter, although the average size is less than one quarter inch. In places such garnet is estimated to form three-quarters of the rock. Two garnet beds noted were each about 6 feet wide and were exposed 200 to 250 feet along the strike, which is about east and west with the dip vertical or about 85 degrees to the south. A little quartz and pyrite are associated with the garnet, and the material cementing the garnet crystals is a fine, clayey material. The garnets of these beds may be valuable as a source of material suitable for the abrasive industry."

In view of the extensive contact metamorphism which has occurred in the pre-Cambrian of Manitoba, other garnet deposits may be expected.

LITHIUM

Lepidolite was found near Star lake several years ago, but it was not until 1924 that any deposits of economic interest were discovered. Since then more attention has been paid to the pegmatites of southeastern Manitoba with the result that some interesting discoveries have been made. Three lithium minerals have been found, viz.: lepidolite, spodumene, and amblygonite (montebrasite variety), having the following composition:

	Percent
Lepidolite $\text{KLi}(\text{Al}(\text{OH},\text{F})_2)\text{Al}(\text{SiO}_3)_3$	lithia = 3.87-5.88
Spodumene $\text{LiAl}(\text{SiO}_3)_2$	lithia = 4.49-7.62
Amblygonite $\text{Li}(\text{AlF})\text{PO}_4$	lithia = 7.92-9.82

Brief descriptions of the outstanding properties follow:

Winnipeg River District—

Silver Leaf Mining Syndicate (Canada) Ltd.

The property of this company lies approximately 10 miles east-northeast of Pointe du Bois and was the first staked for

(*) Geology and Mineral Deposits of the Oiseau river Map-area (Summary Report of the Geological Survey, Dept. of Mines, 1924, Part B, p. 63 and p. 100), by J. F. Wright.

lithium. It has undergone more development than any other lithium property.

On the Bear claim, a pegmatite dyke, cutting through an andesite schist, is exposed for 125 feet in an east and west direction and across an average width of 80 feet. To the south and west a muskeg cuts off further exposures, but pits indicate a greater extension. The mineralization of the dyke shows a zonal arrangement, granite, microcline, and quartz making up the outer part and grading inwardly to a central body of white pegmatite in which alkali feldspars, spodumene and montebrasite predominate, but which also contains two massive lenses of lepidolite near the south side. The spodumene and montebrasite are enclosed by the feldspar and make up about one half of the rock. An area about 90 feet long and 40 feet in width is composed mainly of the spodumene-bearing rock, about one-third of which may be considered lithium ore, hand picking being necessary. One lepidolite lens is 30 feet long and has an average width of 15 feet; the other is 18 feet long and averages 10 feet in width.

The following analysis have been made of lithia ores from this property, (*):

	I Percent	II Percent
Alumina (Al_2O_3).....	26.63	18.13
Lithia (Li_2O).....	3.87	4.76
Soda (Na_2O).....	1.80	0.28
Potash (K_2O).....	9.62	0.11
Iron (Fe_2O_3).....	0.10	0.07
Fluorine.....	4.10	0.16
Phosphoric acid.....	Traces	1.25

I—Sample of compact crystalline lepidolite.

II—Hand picked sample judged to represent approximately the spodumene-bearing rock after 50 percent gangue has been removed.

The Daniel C. Griffith Co., London, England, report as follows, (**):

	III Percent	IV Percent
Silica.....	46.98	36.64
Alumina.....	25.85	25.62
Aluminium Fluoride.....	8.40	.....
Ferric Oxide.....	0.64	2.79
Lime.....	0.36	2.03
Magnesia.....	0.12	0.25

(*) Geology and Mineral Deposits of Oiseau river Map-area, Manitoba (Geological Survey, Canada, Summary Report, 1924, Part B), by J. F. Wright.

(**) Lithium Minerals in Manitoba, by H. B. Lumsden, Issued by Canadian Pacific Railway Development Branch.

The Mineral Resources of Southeastern Manitoba, by J. S. Delury, Issued and distributed by the Industrial Development Board of Manitoba, 1927.

D. C. Griffith Co.'s Report—*Continued*.

Lithia.....	3.98	5.23
Potassium Oxide.....	3.55	1.28
Sodium Oxide.....	6.50	4.40
Ignition Loss.....	3.62	2.60
Phosphorus Pentoxide.....		18.22
Manganese Oxide.....		Traces
Fluorine.....		1.26
Total.....	100.00	100.32
Less oxygen equivalent to Fluorine.....		0.53
	100.00	99.79

III—Lepidolite.

IV—Spodumene.

Active development commenced in 1925, camps being put up, and a compressor, drills, and gasoline engines installed. Three miles of pole tram-line and a winter road were built to a point on the Winnipeg river a short distance below Lamprey Falls. A considerable tonnage of ore has been blasted out and some small shipments made to England, Germany and the United States. Transportation is not difficult as barges may be floated down the river to the railhead, Pointe du Bois.

Other lithium showings have been found nearby, but only a limited amount of work has been done on them.

Bernic Lake District—

Lithium minerals in impressive concentrations have been found in a number of flat-lying sills of pegmatite which break across the highly tilted andesites and sediments on the north and south sides of the valley cut by a creek which flows into the north-east bay of Bernic lake. It is not unlikely that all of these sills are more or less connected at depth. The mineralization is unusual, consisting of spodumene, amblygonite (montebrasite variety), dark orthoclase, flaky albite, and heavy bodies of quartz, with minor amounts of beryl, tourmaline, apatite, mangapatite, purpurite, heterosite, and lepidolite. A zonal arrangement may be observed in some of the exposures, tourmaline with quartz occurring at the top, followed downwards by quartz and orthoclase, spodumene, amblygonite, feldspars, with a heavy body of quartz forming the floor.

Sufficient work has been done to indicate two occurrences of economic interest. The more important exposure is north of the creek where a trench 39 feet in length has been cut, considerably over half of it in lithium minerals. Spodumene predominates, but there is a large amount of high grade amblygonite which could be cobbled out. At the exposure south of the creek,

spodumene crystals, some of them over 2 feet in length, are grouped in mass, and massive individual crystals of amblygonite appear in the quartz.

Cat Lake District—

Several lithium-bearing pegmatites have been exposed near Cat lake, which lies approximately 10 miles north of Bird river, and is probably near the middle of Tp. 19, Rge. 15E.

One half mile north of the lake, a dyke running in an east and west direction across the Irgan claim has been exposed for a distance of 1,200 to 1,500 feet. The east end of the dyke is covered by muskeg and to the west it narrows and branches. The country rock is a basic schist. In width the dyke varies from 10 to 70 feet. The mineralization is complex, but in the main consists of soda and potash feldspars, quartz, spodumene and pale yellowish-green mica with minor amounts of garnet, beryl, native bismuth, and other minerals. The hanging wall-half of the dyke shows most spodumene, some zones containing as much as one half. The deposit has undergone little development, but a large body of lithium ore seems to be indicated.

Another pegmatite about one-half mile south of Cat lake, in a country rock of quartz-diorite shows considerable lithium mineralization over a distance of approximately 100 feet. Only the hanging wall is exposed, hence the width is unknown. The dyke is made up of feldspar, quartz, spodumene, and mica, with other minerals present in small amounts. The spodumene is mixed with quartz in approximately equal proportions.

Prospecting has revealed other deposits just south of the east end of Cat lake. These showings are rather irregular and somewhat difficult to follow. Some spodumene occurs. In one dyke beryl was found.

Uses of Lithium—

Most of the lithium ore which is mined is consumed by the glass industry. By adding finely-ground lepidolite to batches of glass, the viscosity is decreased and by adding still more, an opacifying effect is produced. In the manufacture of opal and white glass and to a lesser extent, flint glass, this is of particular value. The reduction in viscosity is probably due in part to the fluorine content.

Lithium compounds are commonly derived from amblygonite, spodumene being used less frequently owing to its lower Li_2O content. The Edison battery industry ranks next in importance to the glass trade as a consumer, and lithium salts are used in photography, fireworks, signal-lights, and in Roentgen ray work.

Market, Prices, etc.—

The United States produces and consumes the bulk of the world's lithium production. The following statistics give some idea of the magnitude of the industry.

Lithium minerals produced in the United States, 1919-1924:

Year	Short Tons	Value	Year	Short Tons	Value
1919.....	6,287	\$115,000	1922.....	2,192	\$41,300
1920.....	11,696	173,000	1923.....	2,310	38,800
1921.....	1,833	33,508	1924.....	2,996	62,391

Owing to the very limited demand, prices vary considerably. In the United States during 1925, lepidolite carrying two percent Li_2O , sold for \$12.00 per ton, and amblygonite carrying from six to eight percent Li_2O , at from \$50 to \$60 per ton. Spodumene prices are not often quoted, but are said to be \$20 to \$30 per ton. All prices, of course, are strictly dependent on the Li_2O content of the ore.

In Europe, most of the lithium salts are prepared at German chemical works. Probably between 10 and 20 tons of the salts are exported annually to England.

Future Development—

Enough work has been done on the Manitoba lithium deposits to prove the existence of a large reserve of this metal, but the limited demand is retarding development. If the use of lithium minerals and salts increases, however, the province should become an established producer. Electric power at a very low rate is available at the City of Winnipeg's hydro-electric development at Pointe du Bois. Owing to the small demand for lithium salts the setting up of a lithium extraction plant can scarcely be looked for under present conditions.

POTASH

"The rapid decline in the acre yield of many areas in Manitoba is due, largely, to the removal and export—over a term of years—of important soil chemicals, chiefly potash and phosphates, and to the failure to replace these losses." (*) The failure to replace the potash loss of the soil is in great measure due to the lack of workable deposits of this important substance, Manitoba in common with the rest of North America, being de-

(*) Potash Recovery at Cement Plants (Bull. No. 29, Mines Branch, Can. Dept. of Mines, 1919), by Dr. A. W. G. Wilson.

pendent on the French and German deposits. Potash minerals do, however, occur in enormous quantities, but as yet it cannot be said that an economically feasible process of extraction has been discovered. A brief description of three proposed sources follows:

1.—Cement Plants—

During the war, when the European producers were unable to make shipments, considerable attention was bestowed on the possibility of recovering potash salts from the flue dust of cement plants. It was known that these salts were derived largely from the potassium silicates present in the clays or shales which, with limestone, form the raw materials necessary for cement manufacture. Potassium silicates are decomposed at the high temperatures reached in the kilns and escape along with carbon dioxide, carbon monoxide, sulphur dioxide and possibly other compounds, potassium sulphate being formed in greater proportions than other potassium salts. Two general methods were developed for the recovery of these valuable salts and 15 American mills and one Canadian mill installed recovery systems. The mills which were able to market potash while the price was abnormally high, made handsome profits, in some cases paying the entire cost of installation in a very short time. The Canadian mill referred to was the Port Colborne plant of the Canada Cement Co. A spray recovery system was installed shortly after the war, but was not operated commercially and is now idle.

The Canada Cement Co. operates a mill at Tuxedo, near Winnipeg, in which potash salts are being lost daily. The following data (*) indicates this.

Rated daily capacity.....	3,500 bbls.
Raw mix required for 350 lb. barrel of cement.....	580 lbs.
Potash in { Raw mix.....	0.72%
{ Cement.....	0.69%
Potash in daily run of { Raw mix.....	14,616 lbs.
{ Cement.....	8,453 lbs.
Daily loss of potash from kilns.....	6,163 lbs.
Proportion of total potash lost.....	42.1%
Potash lost per barrel of cement.....	1.76%
Estimated Potash in flue dust.....	7.6%

Dr. Wilson states that it is possible to recover at least 60 percent of the potash lost. In 1926 the Tuxedo plant produced 612,155 barrels of cement. Assuming that 1.7 percent potash is lost per barrel of 350 pounds, a total is reached of 1,885 tons of potash; 60 percent of this amount would be more than 1,130 tons, a figure far in excess of the quantity now imported into the province.

(*) Potash Recovery at Cement Plants (Bull. No. 29, Mines Branch, Can. Dept. of Mines, 1919), by Dr. A. W. G. Wilson.

It is probable that under present conditions a recovery process could not operate in competition with the imported potash from France and Germany. On the other hand, however, it must be remembered that chemists on this side of the Atlantic realize the importance of making the North American Continent independent of the European potash producers. It is not unlikely, therefore, that new and more efficient processes may be developed.

2.—The Silicates—

If a refining plant were set up in connection with the lithium deposits of Manitoba, potash would be a by-product of the process. The amount recovered, however, would be very small.

Some of the felspars in the pegmatites of southeastern Manitoba contain high percentages of potash but no process is known by which it could be profitably extracted.

3—Brines—

Prior to 1914 it was thought that potassium salts might be available in considerable quantity in association with the saline springs along the west side of lake Winnipegosis. A number of analysis of brines from these springs had been made, and had shown potassium chloride to be present in as large amounts as 5.2 percent of the total solids. In 1914, however, Wallace (*) collected a number of samples not only from the same springs, but from many others. These on analysis showed a much lower potassium chloride content—from 0.03 percent to 1.20 percent of the total solids. Such a percentage is by no means abnormal and offers no possibilities of profitable extraction.

PULP MILL REQUIREMENTS

Between 260 and 370 pounds of limestone or 150 to 210 pounds of lime are necessary in the manufacture of one ton of sulphite pulp and approximately 500 pounds of lime for one ton of sulphate pulp. Mills making sulphite pulp demand a high calcium limestone if the sulphite liquor is prepared by the Jensen tower system, and a high magnesium lime if the milk-of-lime system is followed. Sulphate or Kraft pulp calls for a high calcium lime.

These materials are available in large quantities in Manitoba, a magnesian lime being burned at Stonewall and to some extent at Garson, and a high calcium lime and limestone shipped from Spearhill. Mills at Port Arthur, Kapuskasing, Smooth Rock Falls, and Dryden in Ontario and International Falls in Minnesota, formerly purchased Manitoba lime in considerable

(*) Gypsum and Brines in Manitoba (XIX, Summary Report, G. S. C., Dept. of Mines, 1914), by R. C. Wallace.

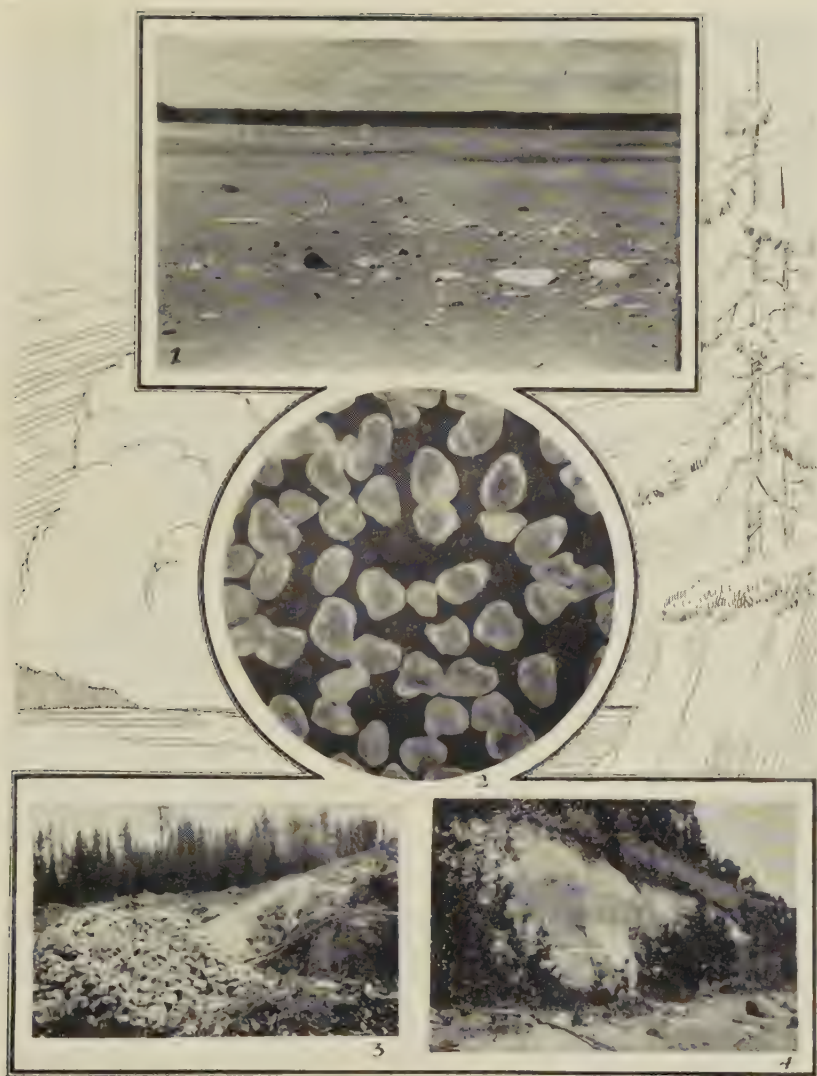


PLATE V.

1. Salt area, Salt Point, Manitoba.
2. Rounded sand grains, Black island.
3. Lithium trench, Pointe du Bois.
4. Winnipeg sandstone, Black island.

amounts, but this business has been captured to a large extent by cheaper American lime. Lime entering Canada must pay a duty, but 99 percent is rebated if it is used in the manufacturing of pulp and paper for export. Furthermore it is claimed that American lime is being dumped on the Canadian market at a lower figure than it brings in the United States. Canadian lime manufacturers are unable to ship to American consumers on account of a high duty.

Prior to 1926, mills at Kenora, Head of the Lakes and Smooth Rock Falls placed their limestone orders with Manitoba quarrymen, but the local rock has been largely superseded by Michigan rock, cheap lake rates making transportation costs very low. The stone enters duty free, being classified as waste rock. Unfortunately the United States does not reciprocate, but charges a duty of \$1 per ton on imported limestone. Shipments from Spearhill to Pine Falls began this year with the opening of the Manitoba Pulp and Paper Co.'s mill. Approximately four cars per week are required.

SALT

No salt beds have been found in Manitoba, but saline waters are common in springs and in some cases in wells.

The Springs—

The salt springs appear throughout a narrow strip of country extending in a southwesterly direction from the Carrot river to the Red river valley, east of the Pembina mountains, and measuring 320 miles in length and 40 miles in width. In every case they issue from Devonian limestones and dolomites and are usually found close to the base of the escarpment which extends from the Pasquia to the Pembina hills. The most important springs occur in the upper beds of the Manitoban formation on the west side of Dawson bay on lake Winnipegosis and on the Red Deer river. A few springs are known west of lake Manitoba, near Crane lake and Westbourne and some appear in the Red river valley near La Salle and Morris. The spring areas are very similar in appearance, consisting of one or more springs bubbling up in the centre of a barren flat, sometimes more than 100 acres in extent, and devoid of all vegetation except the red salt plant.

The dissolved salts in the water from the springs on the west side of lake Winnipegosis average 5.5 to 6 percent. This is much greater than in the southern areas, but compares unfavorably with the brines of Ontario and Michigan which contain from 23 to 25 percent dissolved salts. The flow from 84 separate spring areas has been estimated at 430 gallons per minute, this representing approximately 52,500 tons of salt brought up annually.

The Wells—

South of lake Manitoba the presence of salt water horizons has been ascertained mainly by deep boring. Wells or bore holes have struck salt water at Jamestown, Deloraine, Rosenfelt, Morden, Manitou, Neepawa, Gladstone, Rathwell and Winnipeg. Unfortunately little direct information is available concerning the greater number of these springs. The wells at Jamestown, Deloraine, Morden, Manitou and Rathwell appear to have tapped a flow in the Dakota sandstone. Three horizons were struck in the Neepawa well, the uppermost in the Dakota sandstone, the lower two in the Ordovician and possibly Silurian horizons. Wells at Winnipeg and Rosenfeld showed a flow in Ordovician strata.

The Brine Horizons and their Origin—

Apart from the Dakota sandstone, three brine horizons have been ascertained by borings, viz.:

Horizon	Tapped at	Remarks
Silurian (approximately) at base of gypsum zone.	Rathwell	A 21 ft. bed of gypsum was struck at 960 ft. The water became saltier from 900 ft. down.
Upper Mottled limestone (approximate)	Neepawa	Brine flows at 550 ft., 1185 ft., and 1460 ft. Strongest brines in Manitoba.
Winnipeg sandstone	Elmwood Sanatorium Winnipeg.	Brine flows at 477 ft. and 567 ft. Weak.
	Rosenfeld	Brine flow at 921 ft.

The brine from the wells and springs are remarkably similar in composition though not in concentration. They are less concentrated than brines from salt beds and show a lower percentage of salt and a relatively higher percentage of sulphate. The evidence points to their originating by the leaching of isolated salt crystals in the Palaeozoic strata.

Whenever the Dakota sandstone is tapped at any considerable depth in Manitoba a strong flow of brine is obtained. This has been explained as being due to connate sea water, but the brines contain a greater percentage of salt, a smaller percentage of sulphate and a much smaller percentage of magnesium than does sea water. Moreover the Dakota sandstone represents in the main a fresh water deposition. More in accord with the facts is the theory that the volume of the flow is from the Dakota sandstone water horizon but the dissolved salts from isolated crystals in Devonian strata. The shales capping the sandstone are impervious. Hence, in order to escape, water from the the Dakota sandstone must penetrate downwards into the De-

vonian, leach out isolated salt crystals, and travel laterally through the fissures and openings which characterize the Devonian limestones and dolomites and offer little resistance to the passage of water.

There are then, four salt water horizons in Manitoba, (1) in the Winnipeg sandstone; (2) in the Upper Mottled limestone (approximate); (3) in the gypsum zone of the Silurian (approximate); and (4) in the Devonian series.

Concentration of the Brines—

Brines from the Winnipeg sandstone are very weak, showing concentrations of 3.20 and 4.32 from the Elmwood and Rosenfeld wells, respectively.

Strong brine was obtained in a well sunk to 1,800 feet at Neepawa. The flows at 1,185 and 1,460 feet are thought to be from the Upper Mottled limestone, and possibly from the lower Silurian. They rose to within 285 feet of the top of the well. Analyses show that the brine contains more than 17.00 percent of dissolved salts, over 85 percent of which is salt. A continuous pumping test is necessary to find whether the concentration and flow will remain steady.

Analyses, etc.—

Analysis of dissolved salts of Neepawa brine, (*):

	Grams Per Litre
K.....	0.016
Na.....	71.370
Ca.....	4.096
Mg.....	1.188
Fe & Al.....	Traces
SO ₄	2.875
Cl.....	111.240
Br.....	0.096
I.....	0.015

190.896

	Grams Per Litre
Conventional Combinations	
NaCl.....	181.528
KCl.....	0.031
CaCl ₂	8.042
MgCl ₂	4.603
MgBr ₂	0.110
CaSO ₄	4.073
Fe & Al.....	Traces
MgI ₂	0.016

198.403

(*) The Salt Deposits of Canada and the Salt Industry (Mines Branch, Department of Mines, 1915), by L. H. Cole.

On a percentage basis this works out as follows:

	Percent
NaCl.....	91.4
KCl.....	0.016
CaCl ₂	4.06
MgCl ₂	2.32
MgBr ₂	0.055
CaSO ₄	2.06
Fe & Al.....	Traces
MgI ₂	0.0081

Probable
Salts (*)

	Percent
Sodium Chloride.....	15.29
Magnesium Chloride.....	0.50
Calcium Chloride.....	1.00
Magnesium Sulphate.....	0.32
Magnesium Carbonate.....	0.015

17.125

Bromine present (approximately)..... 0.2

The impurities in this brine calculated to their oxides are as follows, (*):

	Percent
Calcium (as CaO).....	0.50
Magnesium (as MgO).....	0.48
Sulphur Trioxide.....	0.21
The total Chloride in the brine is.....	10.24

Analysis of an Ontario salt bed, (**):

	Percent
Salt, NaCl	99.687
CaCl ₂	0.032
MgCl ₂	0.095
CaSO ₄	0.090
Insoluble water.....	0.017
Moisture.....	0.079

Percent

Concentration of Neepawa brine.....	19.09
Concentration of an Ontario artificial brine (Approximately).....	25.00
Concentration of a saturated brine.....	36.13

No analyses have been made of the brines associated with the gypsum zone of the Silurian. The Neepawa brine may in part come from this zone as pieces of gypsum were found at a depth of 1,005 feet.

(*) Supplied by Mr. T. G. Murphy of the Manitoba Salt Co., Neepawa, Man.

(**) Notes on the Salt Industry of Ontario (Annual Report of the Ontario Bureau of Mines, 1911), by N. L. Bowen.

Historic—

"On the salt springs was based the first mineral industry in Western Canada. From 1800 to 1876 and probably at a still earlier date, freed men from the Hudson's Bay Company service, and in the early years employees of the North-West Company, evaporated the brines from the springs west of lake Winnipegosis and lake Manitoba in iron kettles or troughs, and supplied to all the Hudson's Bay Company posts from Norway House to Fort Qu'Appelle, and to the Red River Settlement as well. In the years prior to 1874 more than 1,000 bushels were manufactured annually at Monkman's springs. The product was reddish in color and deliquescent, but met the needs of the district until the railway brought in the salt from Ontario." (*)

Economic Possibilities—

The brine from the springs is scarcely amenable to the recovery of salt on a commercial basis. It is not only of too low a concentration but it is not sufficiently pure. The most recent attempt to revive the industry took place in 1894 when the Northern Salt Works erected a small plant two miles northwest of Winnipegosis. After being filtered, brine from the springs was led into troughs and was evaporated by means of a fire underneath. This method was a considerable improvement over the kettle process and salt of fair quality was obtained although it was not purified and was somewhat hygroscopic. The enterprise was short-lived, production ceasing in 1896.

It would seem, however, that the brine from the Neepawa well is sufficiently concentrated to furnish the basis for a successful salt industry. Probably the finer grades of salt could not be marketed, in the early stages at least, in competition with the Ontario product, but there is reason to assume that a demand for the cheaper grades could be built up. No doubt a good proportion of the output could be sold for packing purposes, for feeding cattle, and locally as a land salt. When the Flin Flon mine commences operations, large quantities of crude salt will be required in the smelting process, providing it can be laid down at the mine at a considerably lower figure than Ontario salt. Otherwise a system not entailing the use of salt will be adopted. In this connection the fact that the well is less than 50 feet from the Winnipeg-The Pas branch of the C.N.R., is of decided interest.

Some of the brines are said to have a medicinal value apart from their salt content and might be worthy of development for this purpose. Water from the Elmwood well is being used in the baths of the Sanatorium as a cure for muscular ailments. It is also carbonated and sold as a beverage. At Barrows and St. Rose du Lac, brines from Devonian horizons make a very attractive hot weather drink and have a local reputation as a remedy for kidney troubles.

(*) The Mineral Resources of Manitoba by R. C. Wallace, 1927, Issued by the Industrial Development Board of Manitoba.

